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COAL FREEZING PROBLEMS IN RAILROAD CARS:

A State-of-the-Art-Review

P. H. Oosthuizen

Queen's University

Kingston, Ontario, Canada

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ABSTRACT

When coal is transported in rail cars at low ambient temperatures the moisture in the coal tends to freeze causing the coal particles to be bonded together and to be bonded to the surface of the rail car. This makes it difficult to discharge the coal from the cars. Many methods of dealing with this frozen coal problem have been proposed. In the present study, a comprehensive collection of publications on the coal freezing problem was gathered and reviewed. Well over two hundred publications were obtained. Based on a review of these publications, a state-of-the-art review of methods of dealing with the frozen coal problem was undertaken. The information obtained from the publications was supplemented by telephone interviews with a number of persons involved in the Canadian coal industry. A set of applied research projects has been recommended.

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PART A - INTRODUCTION

INTRODUCTION

When coal is transported in rail cars in northern climates in winter-time, some of the moisture in the coal tends to freeze. This causes the coal particles to be bonded together and to be bonded to the sides of the rail car making it difficult to discharge the coal from the car. This problem has, of course, been encountered to various degrees for many years in various parts of the world and many methods of dealing with the problem have been proposed and investigated. This problem has, however, increased considerably in importance in North America over the last couple of decades, the main reasons for this being:

- most of the coal now being transported by rail has been reduced to a fine mesh which tends to lead to a higher surface moisture content and thus to more moisture being available for freezing (see later)
- considerably more coal is being used and, therefore, transported by rail car

The consequences of the coal freezing problem are considerable, the costs of dealing with the problem being very significant and the costs that may result if the cars cannot be unloaded can be large.

THE FREEZING PROCESS

The freezing of the coal occurs, of course, because heat is transferred from the surface moisture surrounding the coal particles to the metal car surface and then to the cold ambient air which is at a temperature below the freezing temperature of water. In most cases, the core of the coal will remain unfrozen while the outer layers along the sides, bottom and top of the car are frozen to a depth of up to roughly 30 cm (see Figure 1). In general, as will be discussed later, the strength of the bond between the frozen coal and the surface of the car is greater than the strength of the bond between the frozen coal particles [173].

THE ROLE OF MOISTURE CONTENT

A number of studies, e.g. see [34], [95] and [207], have indicated that only the surface moisture freezes, i.e. only when the total moisture content exceeds the inherent moisture content will there be a freezing problem. Upon freezing, the surface water bonds the individual particles of coal together and will also bond the coal to the surface of the car.

FACTORS INFLUENCING THE FREEZING PROBLEM

Some of the factors that influence the amount of freezing and the extent of the problems that arise from this freezing are:

- the type of coal
- the amount of surface moisture
- the particle size
- the temperature of the coal when loaded
- the ambient temperature experienced during the rail journey
- the duration of the rail journey
- the impingement of precipitation on the coal during the journey
- the design of the rail car
- the condition of the rail car prior to loading the coal, e.g. whether the car is cleaned prior to loading

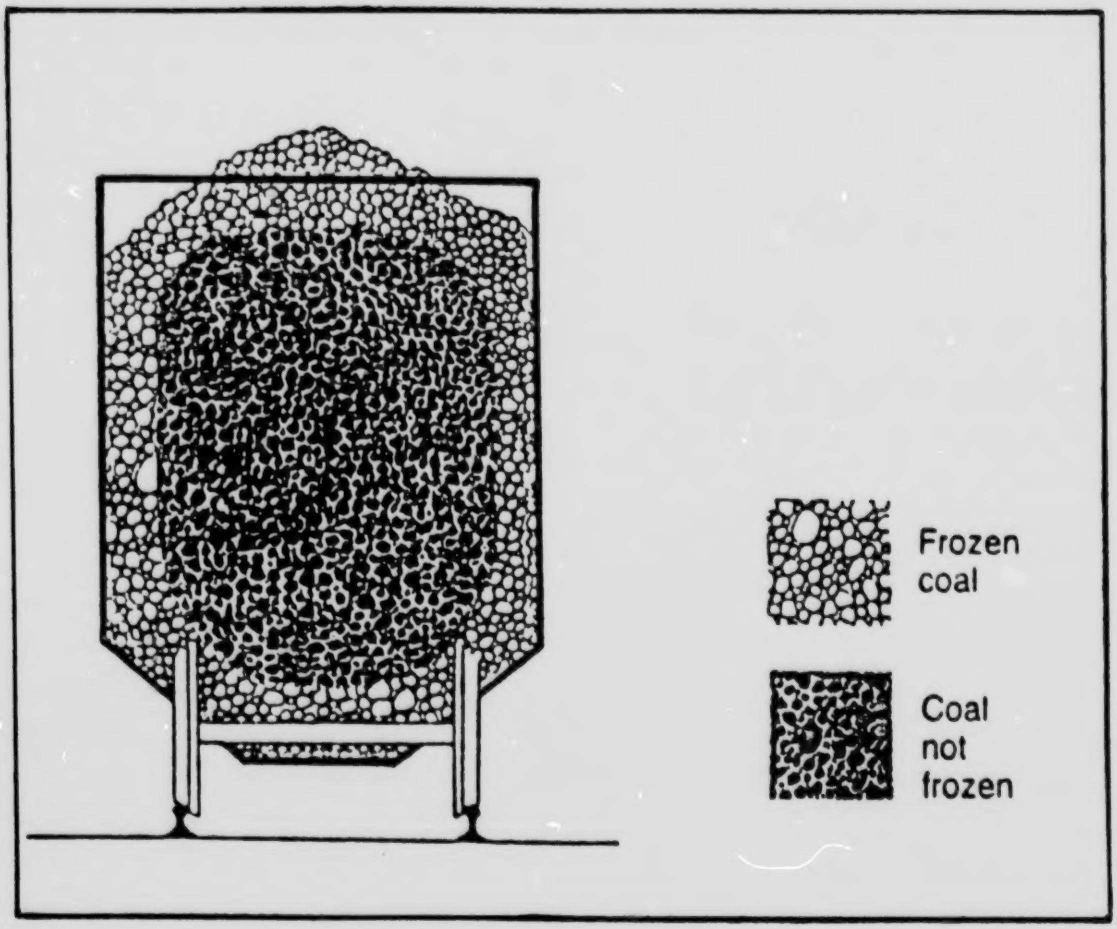
Frozen coal
Coal not frozen

Figure 1. Partial Freezing of Coal in Rail Car [48]

Because these factors vary so widely, it is difficult to arrive at a single universal solution to the frozen coal problem.

POSSIBLE SOLUTIONS TO THE FROZEN COAL PROBLEM

Some of the methods that have been used or proposed to solve the frozen coal problem are:

- heating the surface of the car after arrival at the destination. This can be done in a thaw shed, or in the open using various types of heater.
- mechanical devices. These range from picks and shovels through specialized backhoes to specialized car vibrating devices.
- explosives. There are a number of reports of explosives being used to break up the frozen coal to allow it to be unloaded from the car.
- freeze conditioning agents. These are chemicals which are added to the coal prior to shipment that reduce the strength of the bond between the frozen coal particles.
- surface release agents. These are chemicals that are sprayed on the surface of the car prior to loading that reduce the strength of the bond between the frozen coal and the surface of the rail car.
- anti-freeze chemicals. These are chemicals that reduce the freezing temperature of the moisture.
- Permanent surface coatings. These are coatings applied to the surface of the rail car that reduce the strength of the bond between the frozen coal and the surface of the rail car.

- car design. Various methods of designing the rail car to minimize the frozen coal problem have been proposed.
- Coal treatment prior to loading. The extent of the freezing problem can be reduced by drying the coal prior to shipment, loading the car with coarser coal particles near the surfaces, pelletizing the coal prior to shipment or loading the coal at a high enough temperature to ensure that freezing will not occur during the journey.
- heating the car during the journey to avoid freezing.

As will be discussed later, none of these methods have so far proved to be an economically acceptable universal solution to the coal freezing problem.

Most of the methods of dealing with the coal freezing problem discussed above involve either treatment of the coal and/or the car before shipment or treatment of the coal and/or car after shipment if freezing has occurred. The advantage of the latter approach is that the treatment can be matched to the amount of freezing that has actually occurred. The former approach usually either requires treatment of all shipments for certain months of the year or the use of accurate weather forecasts to decide when treatment should be undertaken.

It should also be noted that since no universal solution to the coal freezing problem appears to exist each situation must, therefore, be individually considered. A solution that proves effective in the United States, where, on average the climate is relatively mild, or in Scandinavia where the journey times are relatively short and where extensive electrification of the rail system exists, may be quite inappropriate to the Canadian situation.

PREVIOUS REVIEWS

While there had been a number of compilations of literature on the freezing problem such as that given in reference [108], the first extensive review of the problem of coal freezing during rail transportation appears to be that of Colijn ([45] and [46]). In the first part of his review he discusses the methods of dealing with the frozen coal problem while in the second part he discusses some operational experiences in various parts of the world. Because of the date at which it was undertaken, Colijn makes no mention of Freeze Conditioning Additives (FCA) or Surface Release Agents (SRA). He does, however, give some discussion of the use of some chemicals that have subsequently been used as FCAs as freeze point suppressants. He also presents a list of suggested research topics.

The severe weather experienced in the United States in the 1970's and the immense coal freezing problems that this caused led to several comprehensive studies of the coal freezing problem. A study for the Department of Energy is described in reference [75] while a study for EPRI is described in reference [186], parts of this study having been given in several earlier publications, e.g. see reference [187] and [188]. A workshop on the coal freezing problem was also held about the time that these reviews were undertaken. A number of papers from the proceedings of this conference are given in the list of references. These reviews were all undertaken at a time when FCAs were first being extensively used and their conclusions largely reflect the great hopes that existed that these would provide the universal answer to the coal freezing problem. These reviews also contain some suggestions for research and development work.

No comprehensive reviews of the coal freezing problem seem to have been done since this time although several brief review articles have been published, e.g. see [48]. As will be discussed later, these later articles tend to indicate that FCAs have not met the high hopes that were initially held out for them and that a combination of methods is really required to completely deal with the problem.

PRESENT STUDY

Although, as discussed previously, there have been several previous surveys of the frozen coal problem these are now either dated or very directly concerned with the situation in the Unites States of America. It appeared necessary, therefore, to undertake a state-of-the-art review with particular reference, as far as possible, to the Canadian situation.

The study involved the following main stages.

- Collection of a comprehensive set of relevant publications and the creation of a data base of these publications
- Using the data base to produce a state-of-the-art review
- A limited survey of the views and experiences of Canadian operators with regard to the coal freezing problem. This survey was carried out by telephone.
- Based on the information gathered, a set of recommendations for applied research projects was developed.

The time frame involved was relatively small and this has been the major factor in limiting the scope of the present study.

PART B - LITERATURE REVIEWED AND DEVELOPMENT OF DATA BASE

The gathering of the literature began basically with the computer searching of various available data bases using the following keywords:

coal

freeze

freezing

frozen

ore(s)

bulk

minerals

rail

railway

railroad

haulage

car

cars

mine

transportation

melting

thawing

additives

In addition to this, the CISTI holdings were computer searched for publications on coal freezing and related topics. Based on these searches and information obtained from other available material, a number of articles were obtained. The references in these articles were then scanned and this led to the identification of a number of other relevant publications which were also duly acquired. In all, well over two hundred publications were acquired.

There do remain a few publications that were identified as relevant but which have, thus far, proved impossible to obtain. Also, in the time frame available, it has not proved possible to search the European literature very thoroughly. However, despite these latter shortcomings, the collection of publications identified is far more extensive than any that has been previously assembled in the open literature. Some of the publications were not available in English. Translations of some of those written in Russian were obtained.

In addition to the publications, information was gathered from some manufacturers of Freeze Conditioning Agents and this has also been incorporated into the publication collection. Copies of a number of patents that are relevant to the coal freezing problem were also obtained and incorporated into the publication collection.

A data base was created with the publications identified using the above procedure. Each publication was given a number, the holding number, and allocated a set of keywords from the following list:

thawing
drying
moisture
storage
unit trains
rail cars
FCA
SRA
thawing agents
calcium chloride
patents
cost

surveys

industry experience

heaters

thawsheds

mechanical devices

safety

testing standards

testing methods

experiments

coal properties

strength

process of freezing

heat transfer

modelling

proposed studies

general discussions

A computer data base which contained the following entries from each publication was then created:

- the allocated publication holding number
- the authors' names
- the title of the publication
- the source of the publication
- the year of the publication
- the allocated keywords

A computer program that could be used to scan this data base was then written. This program allowed the entry of one of the following:

- the names of between one and three authors
- one to three words that appear in the title
- one to three keywords

The program then searched the data base to identify those publications that matched the entered information.

The publications on which the data base is built are listed in Appendices A, B and C. Appendix A gives the references in alphabetical order based on the name of the first author. This list is also numbered sequentially and these numbers are the reference numbers used in the text. Appendix B lists the publications according to keyword, i.e. under each keyword are listed the publications that contain that keyword. Lastly, Appendix C lists the publications according to holding number.

Some publications arrived after the data base was closed and these are listed in Appendix D.

One point that should be made is that the 1980 National Conference and Workshop on Coal Freezing provided a large number of relevant articles. A number of individual articles taken from the full report have been included in the data base. This makes it easier to identify individual articles that are relevant to a particular topic. However, after closing the data base it was decided that for completeness the full report of this conference should be included in the collection of publications. The full report is, therefore, given as one of the late acquisitions

The severe weather conditions that occurred in the United States in the mid 1970s led to a large number of publications on the coal freezing problem. This fact is illustrated by the graph given in Figure 2 which shows the number of publications in the data base for each year between 1960 and 1988.

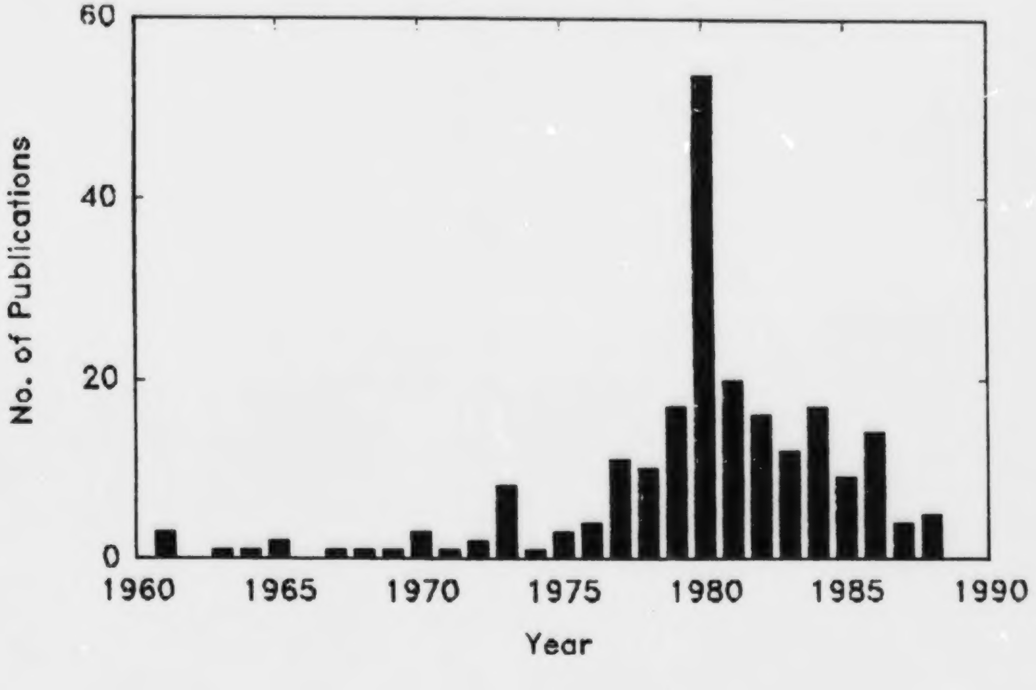

Figure 2. Variation of Number of Publications with Year

PART C - STATE-OF-THE-ART REVIEW

INTRODUCTION

In the present section a brief review of some of the more important information obtained from the publications that are incorporated into the data base will be discussed. No real importance should be attached to the order in which the material is presented although some of the lesser used methods of dealing with the frozen coal problem will be discussed last.

CAR DESIGN AND MATERIALS

Introduction

It has long been realized that the type of rail car being used has an effect on the extent of the freezing problem, e.g. see [49]. For example, experience showed that internal struts and gussets tended to aggravate the freezing problem and increase the amount of coal carried back after dumping, e.g. see Figure 3. In the present section, the effect of car design and possible design modifications on the freezing problem will be discussed.

Car Type

Traditionally, three types of rail car have been used for the transportation of coal, these being:

- the traditional hopper car
- the rapid discharge hopper car
- the gondola type car

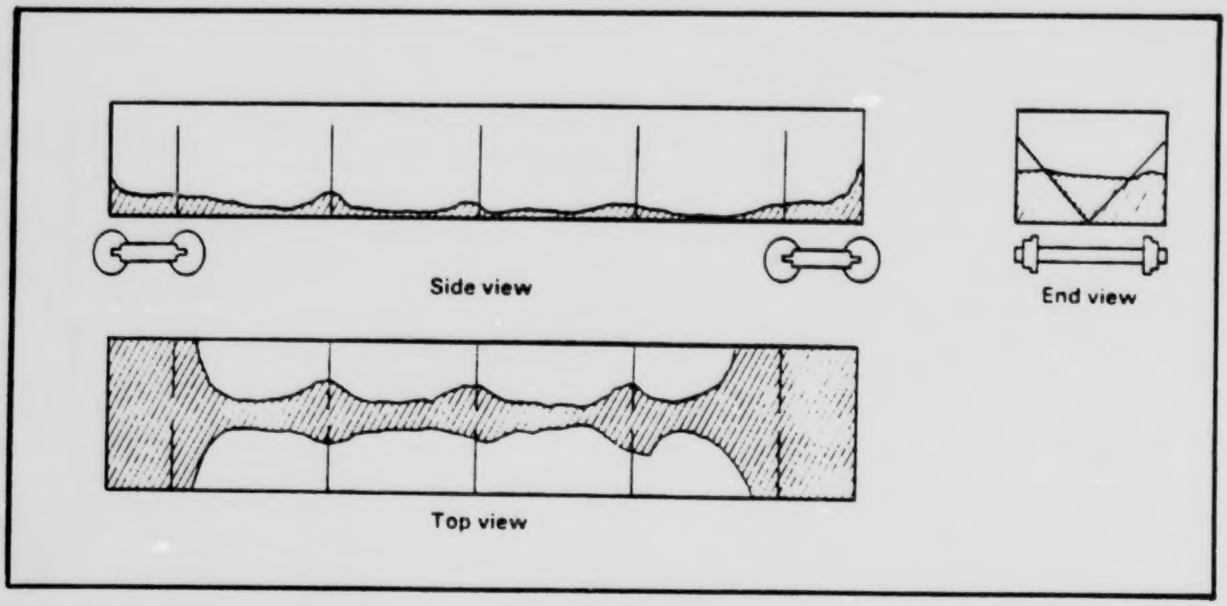
Side view
End view
Top view

Figure 3. Effect of Internal Structure of Car on Carry Back Coal

[134]

The hopper cars are, of course, bottom dumped while the gondola cars are rotary dumped. Considerable discussion has taken place about the relative freezing performance of these types of car. The traditional hopper car often had many internal gussets and freezing around these and in the unloading system generally led to more severe freezing problems with this type of car than with the other two types. Experience with the other two types of car has not shown any clear difference between the freezing performance of the two types although many seem to believe that the performance of the gondola type car is superior if it is well designed with a smooth, rounded inner surface. Gondola cars themselves may be of two types, i.e. the traditional flat bottom type and those with a low slung belly such as the bathtub gondola. In both types, the blockage of the drain holes is often thought to increase the severity of the freezing problem.

It appears that the relative freezing performance of different types of cars is dependent on the method used to deal with freezing if it does occur. If a thawshed is used, the gondola appears to have advantages whereas if FCAs can be used successfully to deal with the freezing problems there is little difference between the performance of hopper and gondola cars.

In conclusion, while the type of rail car used does influence the severity of the freezing problem, it alone cannot eliminate this problem and the type of car used must be such that it matches and enhances the overall system used to deal with the coal freezing problem. In the same way, unit trains can reduce the freezing problem since a single type of car is employed and the procedures used to deal with the freezing problem can be standardized and better designed. When various types of car are used in the train, the thawshed, if used, may not adequately heat all the types of car involved. Also, if chemicals are used, such as SRAs, they may not be adequately applied to all types of car involved. If trains consisting of different cars are used. treatment of the coal prior to loading may be the best method of dealing with the freezing problem.

Car Material

It might be expected that the type of metal from which the car is constructed, e.g. steel or aluminum, may influence the extent of the freezing problem since the bond strength between the frozen coal and the car surface is influenced by the type of material from which the car is made and because the thermal conductivity of the car material could influence the freezing and thawing processes. Operationally, however, there does not seem to be significant reported differences between the performance of aluminum and steel rail cars. It appears that factors other than freezing will determine the type of material used [98]. It may be noted that, contrary to the opinions expressed by some, aluminum rail cars are not in any way damaged in conventional well-designed thawsheds.

Car Surface Insulation

If the surfaces of the rail car are covered with a layer of insulation the rate of heat transfer through the walls of the car will be reduced and the rate at which the coal in the car freezes will be reduced. If the journey is short enough then the insulation can prevent freezing from occurring. In the early 1960s a study of the effectiveness of a polyurethane foam insulation in reducing the freezing problem in rail cars carrying various types of iron ore was undertaken by U.S. Steel Corporation [45]. Both laboratory and field tests were undertaken. These tests clearly indicated that the addition of the insulation did reduce the extent of the freezing problem. Similar conclusions were reached in a later numerical study [162]. It must, however, be realized that while the addition of insulation to the surface of the car will reduce the rate at which freezing occurs it will not prevent freezing from occurring if the car is subjected to sub-zero ambient temperatures for a sufficiently long period of time. If this occurs, the presence of the insulating layer on the surface will make it more difficult to remove the frozen coal if surface heating is used. The insulation must also be protected from damage and this can make its application expensive.

It has been suggested that various types of sandwiched materials should be used in the actual construction of the rail cars [45]. This panel material would include a core made of an insulating material and the use of such materials would, therefore, potentially reduce the freezing problem.

It would appear that the use of surface insulation to reduce the freezing problem will be of most use in the transportation of high conductivity ores over short distances rather than in the transportation of coal.

Liners and Coatings

A number of investigations of the effectiveness of either lining the car or permanently coating the inside of the car with a material that prevents the adhesion of the frozen coal to the car surface have been undertaken [188], [215] and [38]. The biggest problem with this method of reducing the freezing problem is that the liners or coatings are often damaged during loading and unloading and the damaged surfaces sometimes increased the severity of the freezing problem. Plastic vinyl liners have been tested in the United States and the test results indicated that there were no discernible differences between the volumes of coal retained after dumping for the lined and unlined cars [128]. Low friction coatings have been investigated in the USSR and elsewhere in Europe and the results have been relatively positive. Low friction paints have been tested in the UK and there too the initial results are positive [38].

It appears that low friction coatings that are economically acceptable and which may reduce the extent of the freezing problem are available and their application under Canadian conditions requires investigation.

Heat Application During Transit

It is, of course, possible to heat the coal in the rail cars during transit and thereby prevent the freezing problem from occurring. A number of possible systems have been proposed but none have, as yet, been widely accepted in North America. Of course, applying or removing heat from a car is, in general, a widely accepted procedure. Refrigerated cars, each with their own refrigeration unit are widely used for the transportation of perishable commodities. The success achieved with this equipment has, however, not led to the development of coal cars with in-transit heating. This is due primarily to the lower value of coal as compared to that of most perishable commodities. Moreover, the number of months in the year during which heating is required is generally small which also makes the heating systems relatively expensive. Heating of the rail cars if done electrically or with steam would in North America require a special energy package to be mounted somewhere in the train. In electric railroad systems, resistance heating of the cars is much more easily accomplished and in some cases much success has been achieved [47].

At the present time it appears that in-transit heating is not economical in the Canadian situation.

Destination Heating

Instead of electrically heating the car during transit, it has been suggested that the car should have built into them resistance heating elements or induction heating coils [45]. When the cars arrived at the destination point, power would be applied if necessary to the electrical heating system allowing the coal to be discharged from the car. Some investigation of this system was undertaken in Germany [45] where induction heating was found to be better than resistance heating. This method of dealing with the freezing problem appears to be technically feasible but its economic feasibility in the Canadian situation has not been investigated.

Rail Car Covers

Considerable attention has been given to removable covers for rail cars. The main purpose of these covers is to prevent dusting. However, the use of such covers could reduce the severity of the coal freezing problem because they would prevent the impingement of ice, snow and rain on the coal during the journey and in the empty cars during the return journey.

Some of the considerations that enter into the selection of covers for coal cars are discussed in publications with the holding number 231 and 233 given in the list of late acquisitions. Many different materials have been suggested and the problems associated with the use of covers on cars that pass through a thawshed are discussed in the publication with the holding number 231 given in the list of late acquisitions. It is generally believed that a system in which the covers are removed prior to the car entering the thawshed and then replaced after the unloading is completed is the best.

Covers with built in heaters that help to prevent freezing during the journey have also been considered.

While the use of covers is unlikely to be dictated by coal freezing problems alone, they could be of considerable benefit in an overall system for dealing with the coal freezing problem. For example, the effectiveness of FCAs can diminish considerably if significant amounts of rain fall on the coal during its transport. The use of covers could, therefore, increase the effectiveness of FCA. Of course, at the present time it appears impossible to economically justify the use of both FCAs and rail car covers.

FREEZE CONDITIONING AGENTS

The major new method of dealing with the frozen coal problem that has come into relatively common usage during the past ten years is the use of Freeze Conditioning Agents (FCAs). These are chemicals that are mixed with the coal prior to loading it into the rail cars in order to reduce the bond strength between the coal particles after freezing occurs. It must be clearly understood that the FCAs are not used to prevent freezing. They will, of course, produce a small depression in the freezing point but their major purpose is to promote the formation of an ice that is structurally weak. A typical relation between compressive strength of frozen coal and FCA concentration is shown in Figure 4.

Available FCAs are salt, oil or glycol based. Glycol based FCAs have received the most attention and are usually made from one or more of the following types of glycols:

- ethylene
- propylene glycol
- diethylene glycol

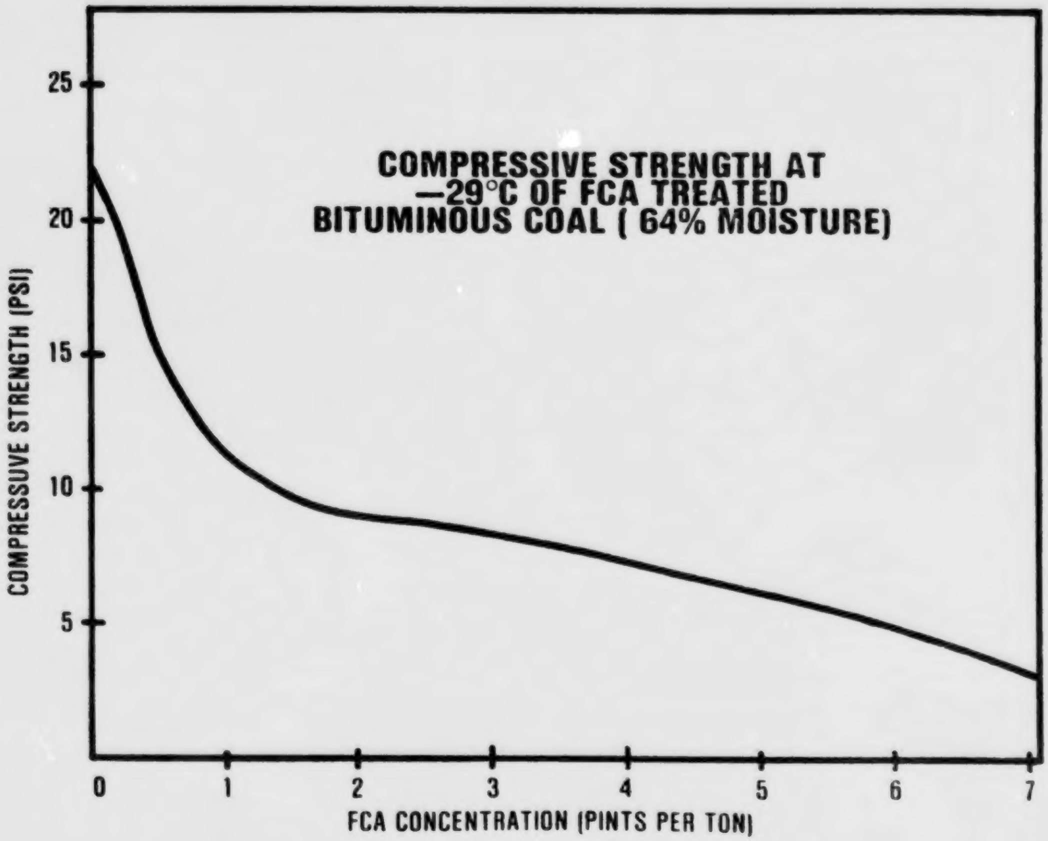

Figure 4. Variation of Compressive Strength of Frozen Coal with FCA Concentration [190]

- dipropylene glycol

Many of the glycol based FCAs have patented formulae. e.g. see [174] and [186].

Some difficulties have been experienced with glycol based FCAs. High porosity coals can absorb this type of FCA and thus considerably reduce their effectiveness. When the coal has rain or snow fall on it during the journey, the effectiveness of glycol based FCAs is also considerably reduced. Some attempts have been made to develop FCAs that may overcome this latter problem.

Oil based FCAs are not strongly affected by precipitation although in some cases the presence of the oil based FCAs has caused the formation of separate pockets of water which cause considerable problems upon freezing. Of course, one advantage of oil based FCAs is that they increase the effective heating value of the coal. FCAs based on light oils have proved to be essentially as effective as glycol based FCAs if the ambient temperature remains relatively moderate with low ambient temperatures, however, oil based FCAs have relatively little effect. Oil based FCAs have usually proved to be relatively more expensive than glycol based FCAs.

Most salt based FCAs are made from a calcium chloride solution. However, this type of FCA has little advantage over glycol FCAs and their use has raised fears of possible equipment corrosion. For these reasons, calcium chloride is usually used in some other way in dealing with the frozen coal problem.

The effectiveness of FCAs depends very much on the proper application of the FCA to the coal before it is loaded into the car. Usually, this is done using some form of spray system at belt discharge points just prior to rail car loading, e.g. see Figure 5. However,

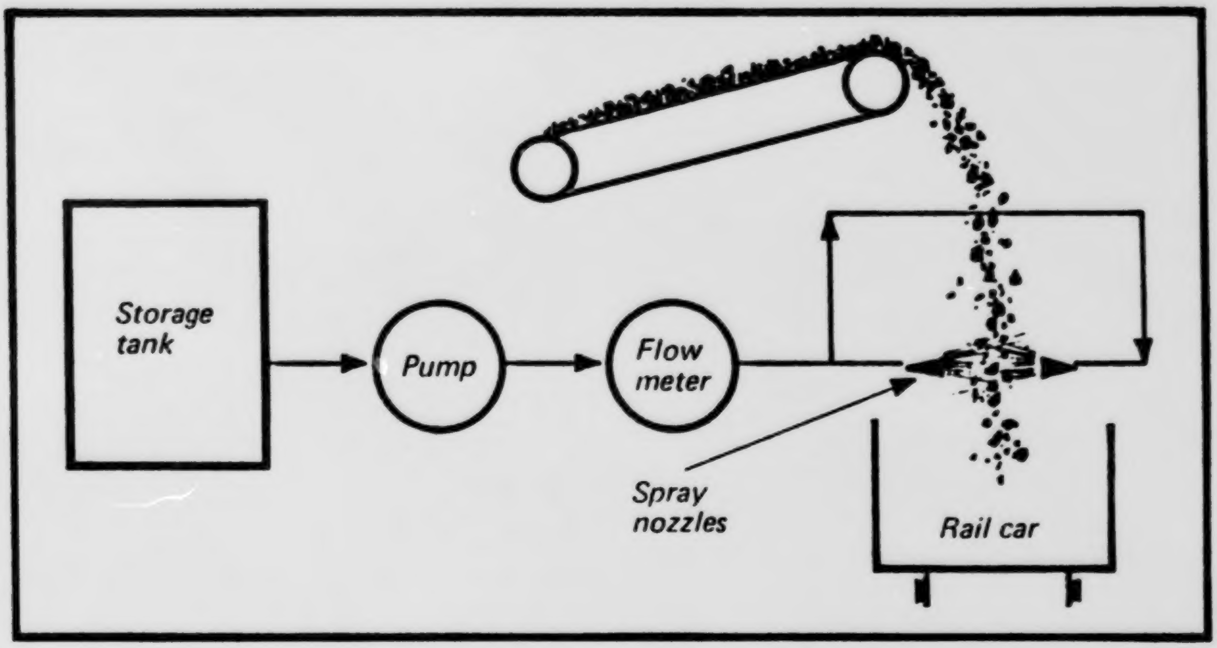
Storage tank
Pump
Flow meter
Spray nozzles
Rail car

Figure 5. FCA Spray Application [99]

multipoint applications of the FCA may, in some cases, be necessary and the spraying of a small amount of FCA on top of the coal after it is loaded into the rail car is also often undertaken. It must be realized that for reasons that will be discussed to a limited extent later, FCAs are only effective in reducing the bond between the coal particles and often have little effect on the bond between the frozen coal and the surface of the car. For this reason, when cars that contain coal treated with an FCA are dumped a fairly considerable amount of coal may, in some circumstances, remain attached to the surface. This is often called "slabbing". While economically not very attractive, it is for this reason that a combination of thawshed and FCA application is sometimes used, the thawshed in this case not requiring much equipment to break up the frozen coal that is dumped from the car.

The cost of FCAs has risen considerably since they were first used and today they are often considered an uneconomical solution to the coal freezing problem, particularly in view of their limited effectiveness under the climatic conditions often encountered in Canadian applications. Depending on the expected weather conditions and the individual supplier recommendations, these chemicals are normally applied at a rate of 0.00025 to 0.001 litres per kilogram (about 1/2 to 2 US pints per short ton), e.g. see [48].

SURFACE RELEASE AGENTS

The strength of the bond that forms between the frozen coal and the sides of the car is usually much stronger than the bond between the coal particles. Many reasons have been given for this, the most common one being that because the coal near the surface is at a lower temperature than the coal away from the surface, there will be a thermally induced migration of moisture in the coal towards the sides of the car. This would lead to a higher surface moisture content near the car surface and, therefore, a stronger frozen bond. There is, however, little theoretical support for this hypothesis. Ice and snow buildup on the empty rail car sides and bottoms prior to loading can also increase the moisture content of the coal near the surfaces. The nature of the bond between the water and the metallic car surfaces is also different from that between the frozen coal particles. Side Release Agents (SRAs) are liquids that will reduce the strength of the bond between the frozen coal and the car surface when sprayed on the surface of the car prior to loading the coal.

A number of chemicals have been considered for use as SRAs. Glycol based chemicals tend to be ineffective because they tend to reduce the surface tension of the water allowing it to more easily "wet" the sides of the rail car with the result that they often aggravate the surface freezing problem [205]. Other materials that have been used as the basis for SRAs are hydrocarbon oils, various polymers, lignosulfonate and calcium chloride. While most SRAs are chosen to prevent the moisture from wetting the car surface thus preventing the formation of a frozen bond at the surface, those that are based on a calcium chloride work by depressing the freezing point of the water near the sides of the car to a low enough value to prevent freezing in this area [103]. If the moisture content near the surface becomes high due to precipitation the calcium chloride based SRAs may become so dilute that they become ineffective.

The effectiveness of an SRA depends very strongly on the proper application of the SRA to the car surface [87]. This is usually done using some form of spray system such as that illustrated in Figure 6. The high viscosity of the SRAs often make this a difficult task. Poorly designed rail cars with internal struts and sharp corners are also difficult to spray uniformly.

SRAs are really still in the developmental stage. Some have reported them to be very effective while others have reported disappointing results. Part of the problem is that no

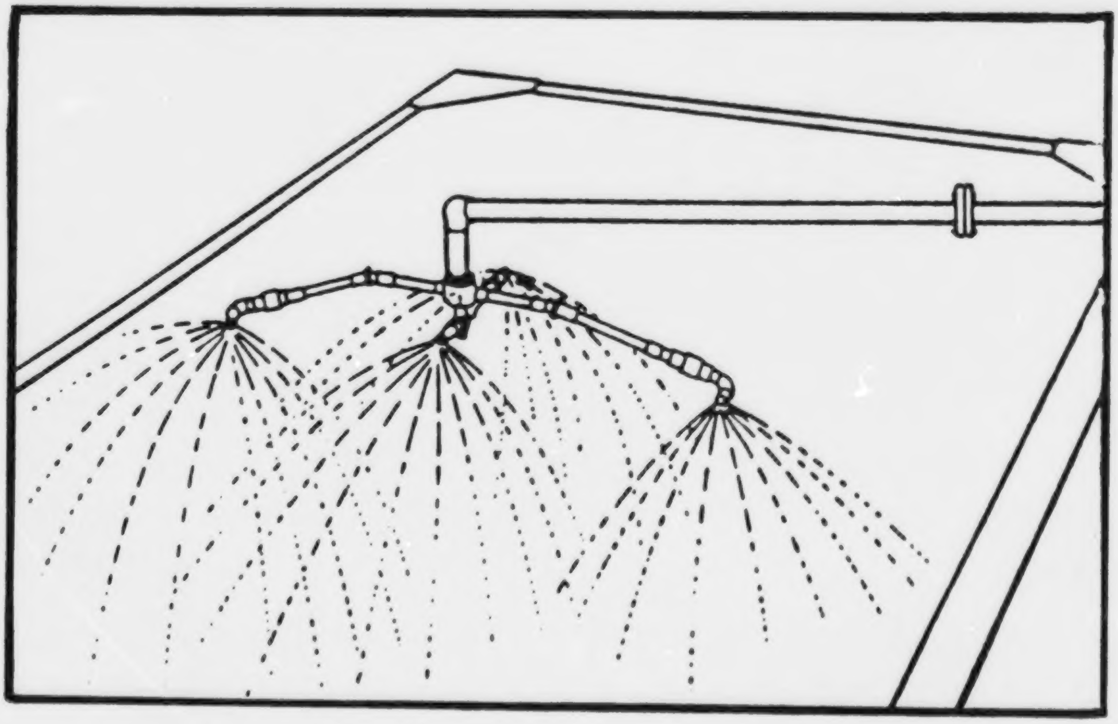

Figure 6. SRA Spray Application [4]

extensive body of experience concerning their use has yet been developed. For example, one SRA application may, in some situations, be good for several trips but in other situations a new application may be required for every trip. The exact conditions that determine whether an application of SRA will be effective for more than one trip are not well established.

SRAs seem to have considerable potential but more testing, particularly in the Canadian situation, is required to determine whether this potential will be realized and whether their use will be economically feasible.

MECHANICAL DEVICES

Introduction

The mechanical devices here being discussed are those meant to break up the frozen coal in the car thus allowing it to be discharged from the car. Of course, the simplest mechanical devices, i.e. the pick, sledgehammer and shovel, have long been used for this purpose and continue to be used though mainly for emergency purposes. The biggest problem with many of the mechanical devices that will be discussed below is that they can potentially cause considerable damage to the cars.

A summary of some mechanical devices, based on that given in reference [186] is given in Table 1. These, and other mechanical devices are discussed below.

MECHANICAL DEVICE	DESCRIPTION	EFFECTIVENESS
AIR RAMS		
Coal Breakout Machine	Backhoe. Hydraulic Boom and Large Air Hammer or Vibrator-Platform Mounted (1800-2000 psi)	Fair
WATER JETS		
Water Blasters	Up to 10,000 lb psi nozzle pressure	Effective
Water Jets	Fire Hose Nozzles	Effective when used with hot water
AIR CANNONS		
Bulk Breaker	Pneumatic-up to 10,000 psi	Emergency Use
Hopper Popper	Hydraulic and Pneumatic -3 hollow drills forced down into coal	Emergency Use
VIBRATORS		
Vibrating Pile Discharger	2 hp drive motors on hopper under pile	Effective
Vibratory Pile Hammer	Hydraulic, 1500-1800 cycles per minute	Emergency
Dumper Vibrators		Works
Vibrating Air Hammer	Oscillating	Works
CAR SHAKERS		
Heavy Duty Car Shakeout	6 ton, 1200 cycles/min.	Effective - can damage some cars
Car Shaker	5 ton, 1100 cycles/min.	Effective - can damage some cars
Trackside Car Shakeout	2800 lbs, lateral thrust on outside of car (electric) or pneumatic)	Limited for special situations
COAL BREAKERS (Frozen Coal)		
Frozen Coal Cracker	Chain Drive 60-150 hp	Good
Hammer Mill	Electric, Belt Drive 40-60 hp	Good
CAR HOE		
Car Hoe	Hydraulic, Pedestal Mounted can be operated by remote control. spade nozzle	Works when really needed

Table 1. Table of Mechanical Devices [186]

Vibrating Hammer

Various types of vibrating hammer have been used and proposed. These consist of a pile connected to a vibrator (see Figure 7). The system is lowered onto the coal in the car and is used to break through the frozen top crust and then down to the bottom of the car. This type of vibrating hammer can be lowered onto the coal either by crane or by some form of back hoe-type machine and it is, of course, repeatedly inserted into different parts of the car.

An extension of the basic vibrating hammer is the so-called Galloping Gertie. This consists, basically, of a series of thirty or more pointed beams which are driven by large vibrators and are lowered into the rail car as a unit (see Figure 8).

A number of mechanical car shakers have been used and proposed, see [45], [186], [187] and [212]. All of these vibrate the entire car in an effort to break up the frozen coal and to break the bond between the frozen coal and the sides of the car, see Figures 9, 10 and 11. The biggest disadvantage of such mechanical shakers is the potential to damage the cars and the high level of noise associated with their use. The disadvantages of mechanical shakers would not exist if an ultrasonic vibrator could be developed. The use of such devices was suggested in references [212] and [214]. Basically, it would involve the insertion into the coal or attachment to the car of a series of transducers. The bottom of the cars would be used as the resonator. These ultrasonic vibrators would excite the ice molecules causing

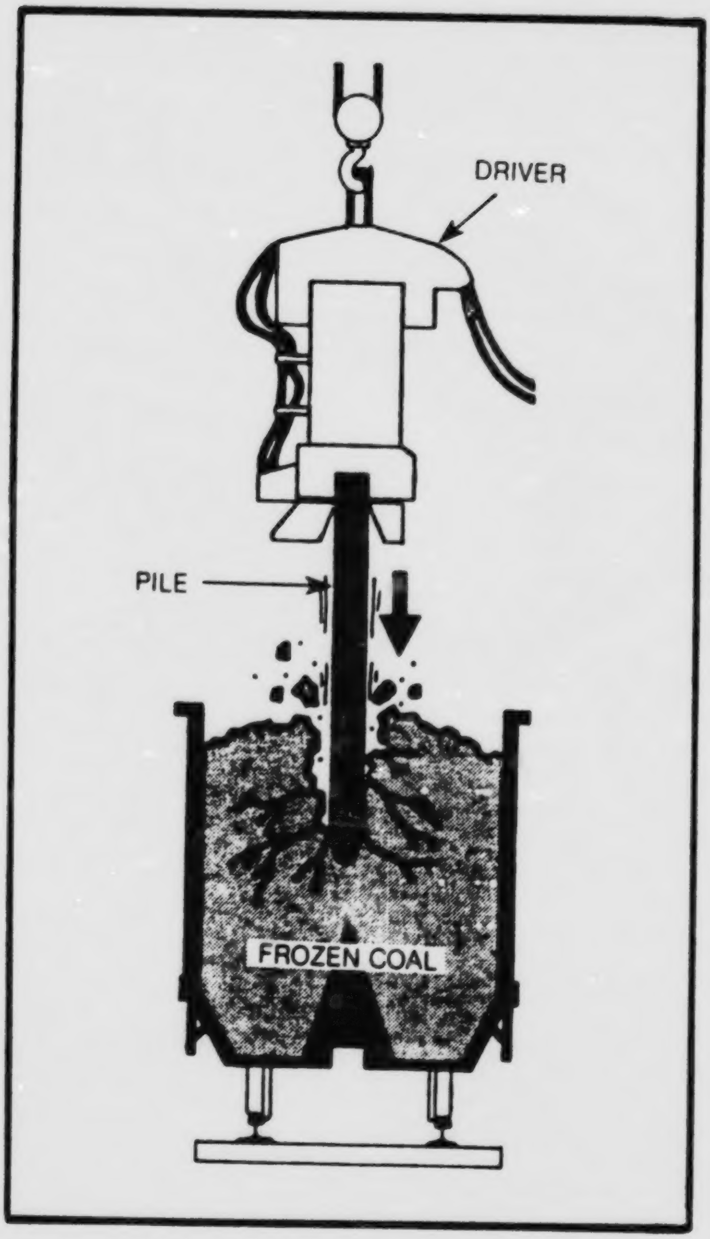
DRIVER
PILE
FROZEN COAL

Figure 7. Vibrating Hammer [186]

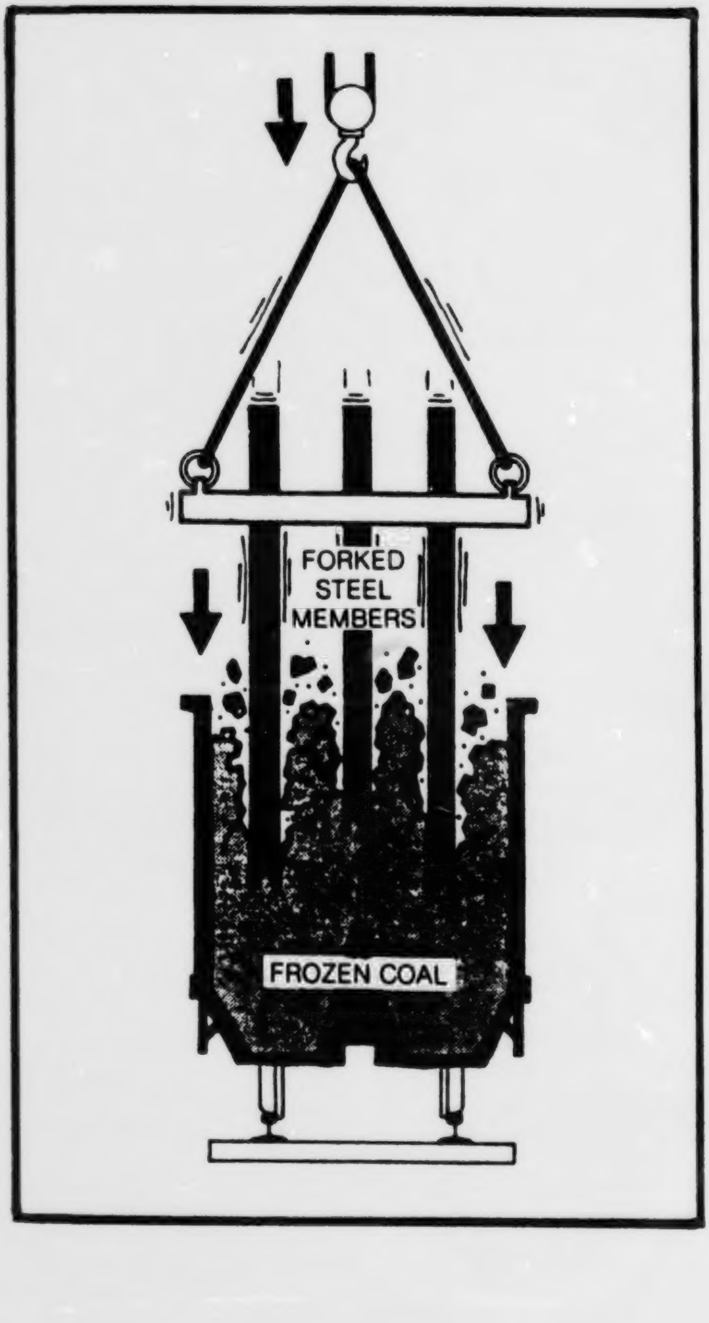
FORKED
STEEL
MEMBERS
FROZEN COAL

Figure 8. Galloping Gertie [186]

the ice to rupture. No successful implementation of this type of device is known to have occurred.

Car Hoes and Back Hoes

These devices either push or pull the material towards the opening in the car thus easing its discharge or they may be equipped with a vibrating head of some type which has steel pointed tools to allow the device to break up the frozen coal.

A car hoe is shown in Figure 12. It is essentially a back hoe mounted on a steel tower alongside the track at the unloading point. It is operated from a seat on top of the boom or by remote control from a vantage point above the car. The end of the boom is usually equipped with a small flat shovel-like blade which is used to push or pull the coal.

Back hoes are used in the same basic manner as car hoes. They may, for example be mounted on steel rails which transverse tracks over the unloading area.

These devices have tended to be used to deal with emergency situations.

Air Cannons and the Hopper Popper

Basically, an air cannon is a device which drills a hole in the frozen coal and then releases air under very high pressure through the hollow drill bit or auger [186] (see Figure 13). The release of the high pressure air results in an explosive force which shatters the frozen coal. The procedure does, in some cases, create considerable amounts of dust following the air "explosion". However, they have proved effective in emergency situations.

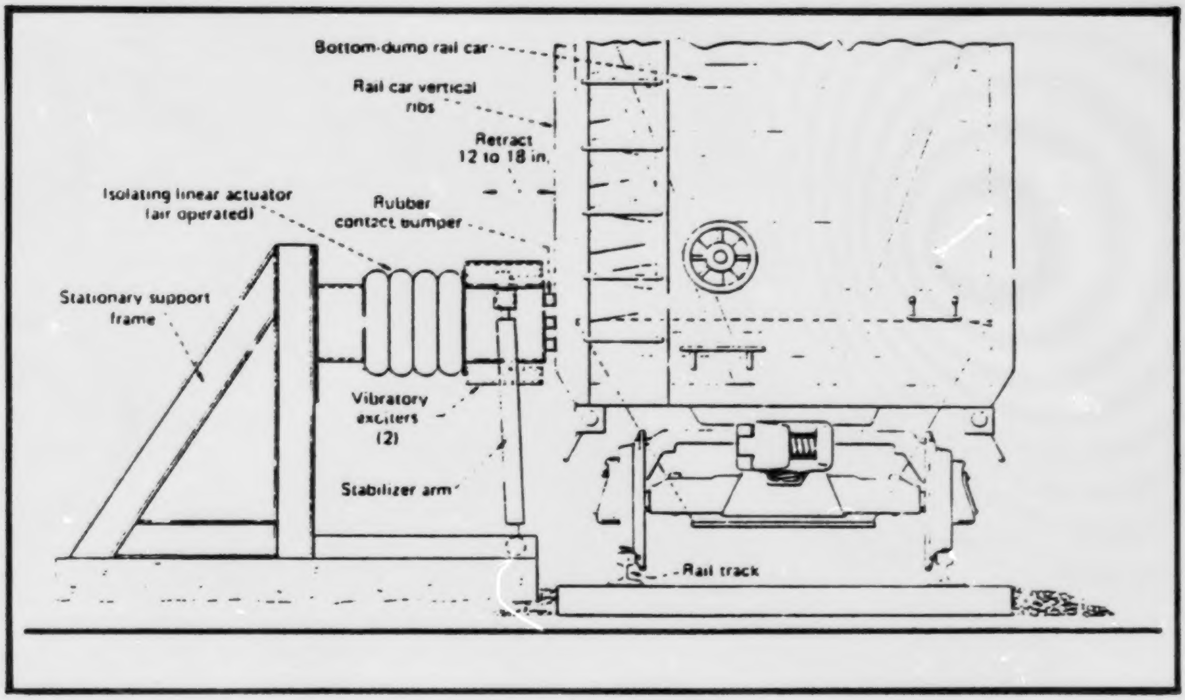
Bottom-dump rail car
Rail car vertical ribs
Retract 12 to 18 in.
Isolating linear actuator (air operated)
Rubber contact bumper
Stationary support frame
Vibratory exciters (2)
Stabilizer arm
Rail track

Figure 9. Car Vibrator [212]

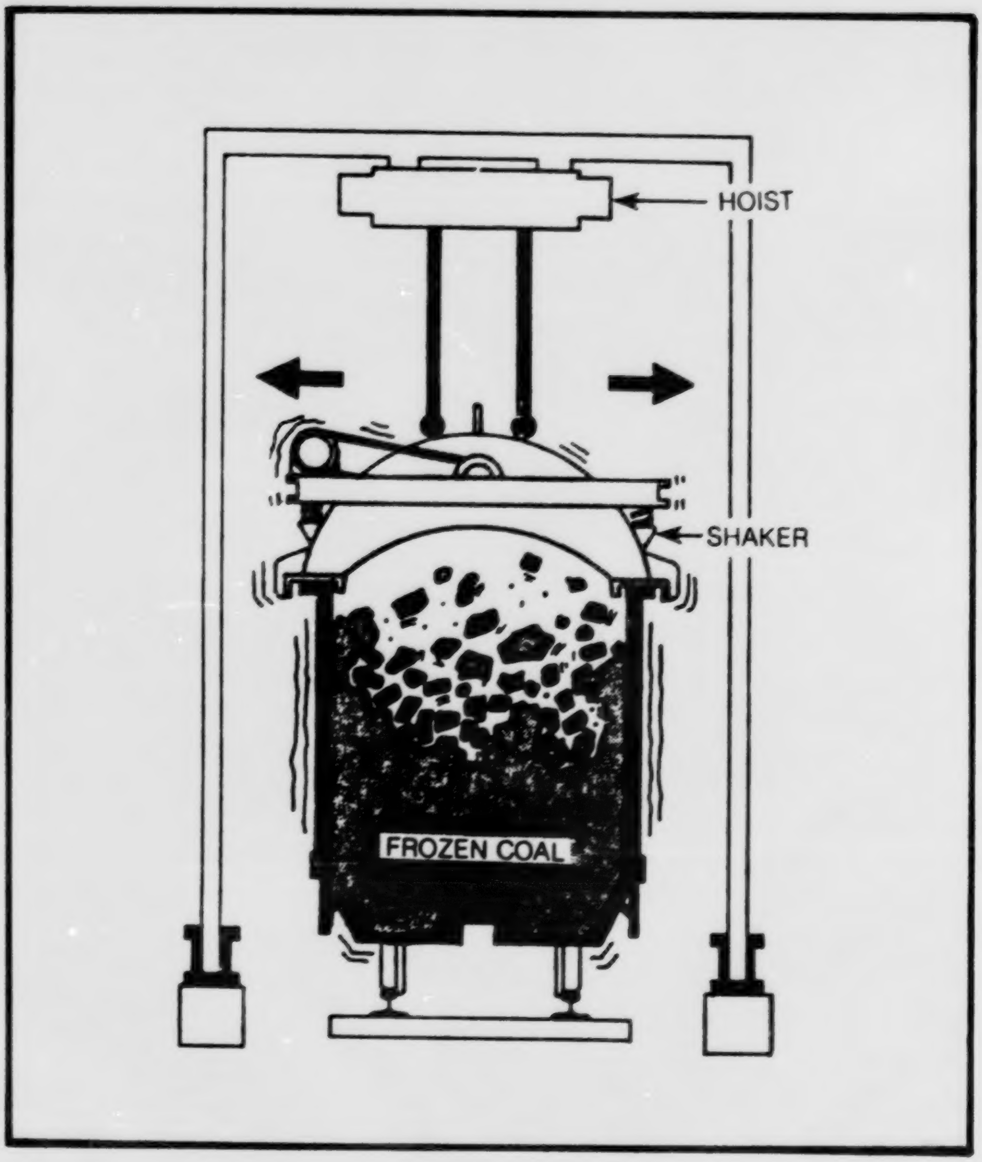
HOIST
SHAKER
FROZEN COAL

Figure 10. Car Vibrator [186]

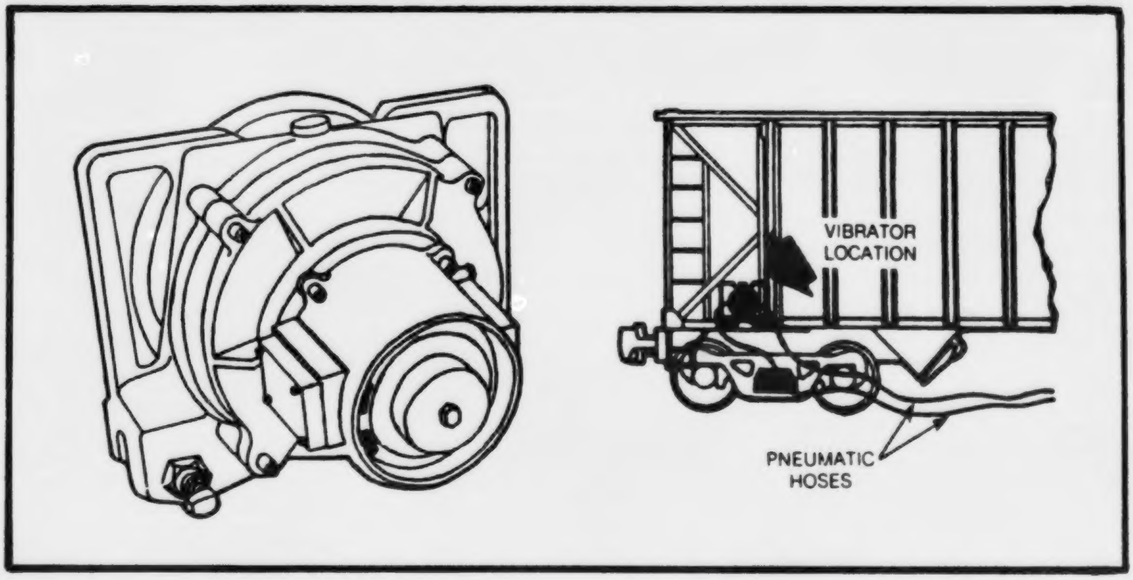
VIBRATOR
LOCATION
PNEUMATIC
HOSES

Figure 11. Car Vibrator [186]

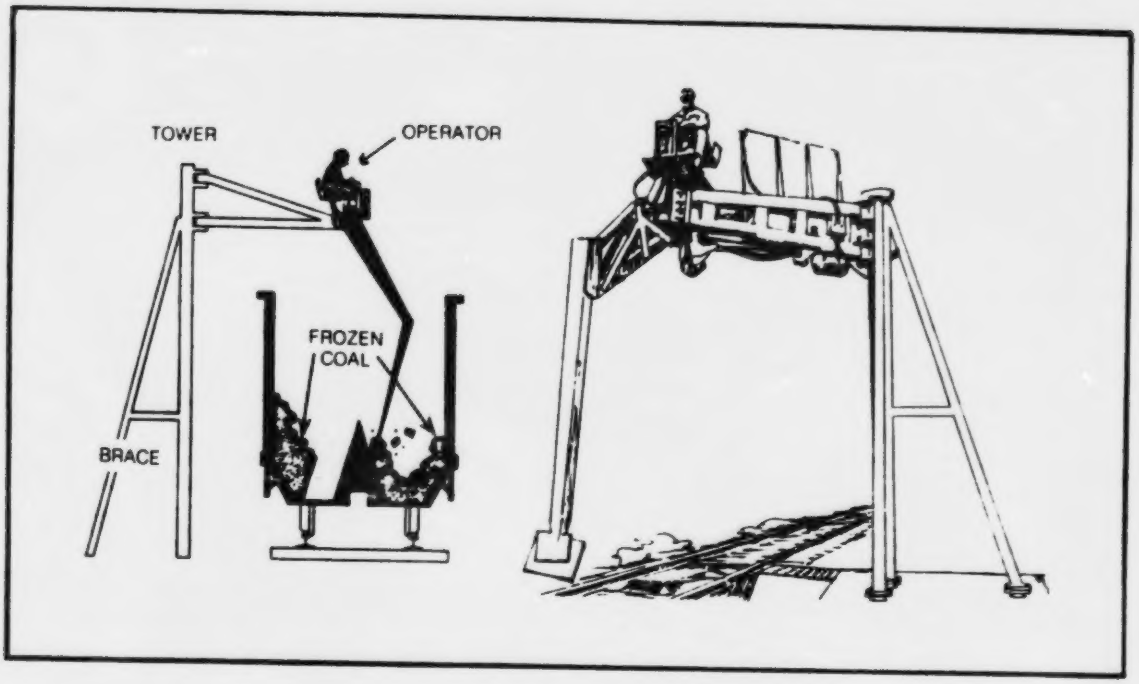
TOWER
OPERATOR
FROZEN
COAL
BRACE

Figure 12. Car Hoe [186]

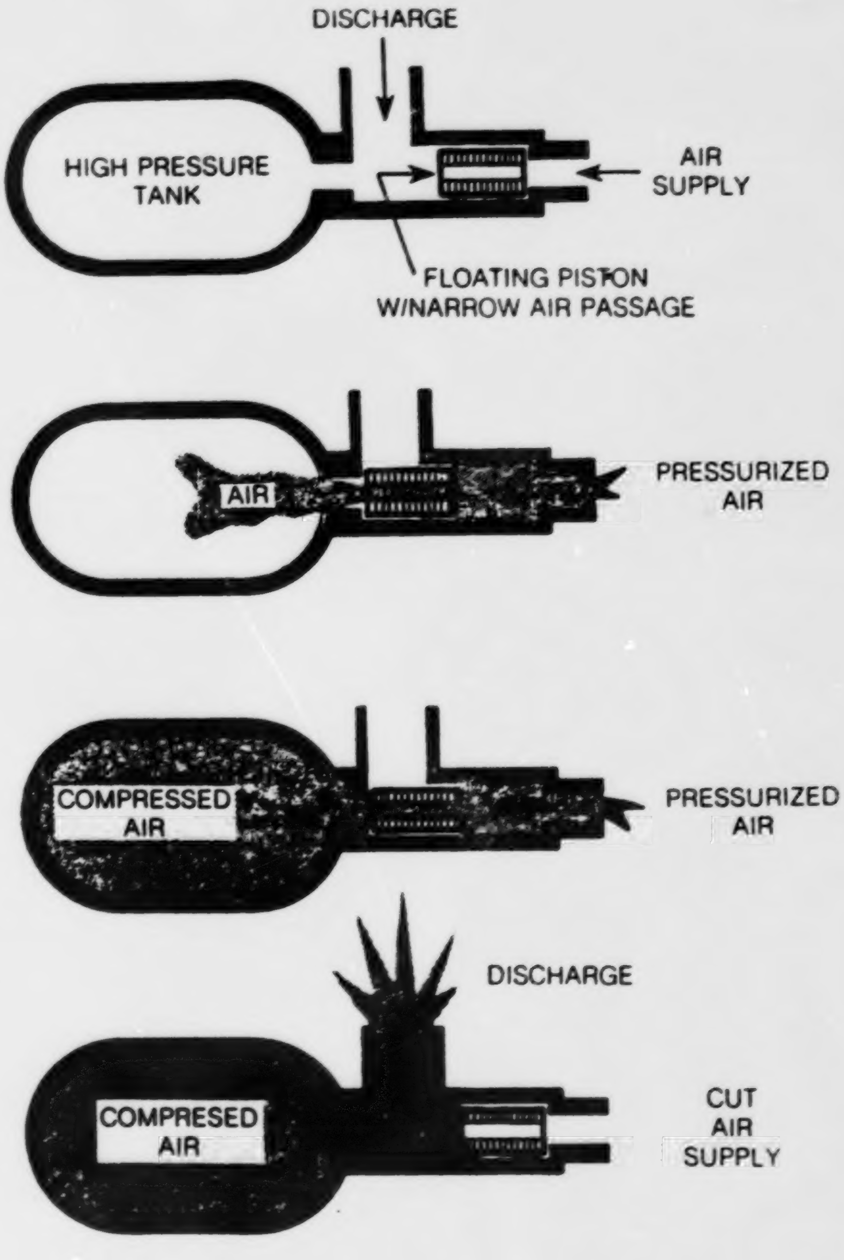
DISCHARGE
HIGH PRESSURE TANK
AIR SUPPLY
FLOATING PISTON W/NARROW AIR PASSAGE
AIR
PRESSURIZED AIR
COMPRESSED AIR
PRESSURIZED AIR
DISCHARGE
COMPRESED AIR
CUT AIR SUPPLY

Figure 13. Air Cannon [186]

The "hopper popper" consists basically of three drills with air cannons built on a rail-mounted machine above the tracks [7] (see Figure 14). An operator positions the drills, drives them into the coal using hydraulic pressure to a selected depth and then fires the air cannons. The air is supplied by a series of compressors together capable of generating pressures of up to 12,000 psi.

Explosives

It has frequently been reported that under emergency conditions, dynamite has been used to break up the frozen coal in a rail car. Although these reports mention the use of only a small part of a stick of dynamite, this uncontrolled use of dynamite must be regarded as an unsafe and unsatisfactory practice. However, some testing of the more controlled use of explosives has shown some promise. In this procedure, tubes are placed in the coal at the loading point [212]. Specially shaped and weighted explosive charges are then inserted down these tubes at the destination and used to shatter the coal in a planned manner. The high demands for safety and the need to have experienced blasting personnel to handle the firings have mitigated against this procedure being used on a routine basis.

An alternative method of using an explosion to break up the frozen coal was proposed by NASA [207]. In their procedure, a lance-like probe (see Figure 15) is inserted into the frozen coal and used to introduce a measured quantity of two gases, one a fuel and one an oxidant, into a relatively small and confined volume of the coal. The gas mixture would then be detonated by an electric spark creating a shock wave to break up the frozen coal around the point at which the gas is introduced. This process would be repeated at several locations in the rail car. Typical gases used would be acetylene, propane, butane or methane with

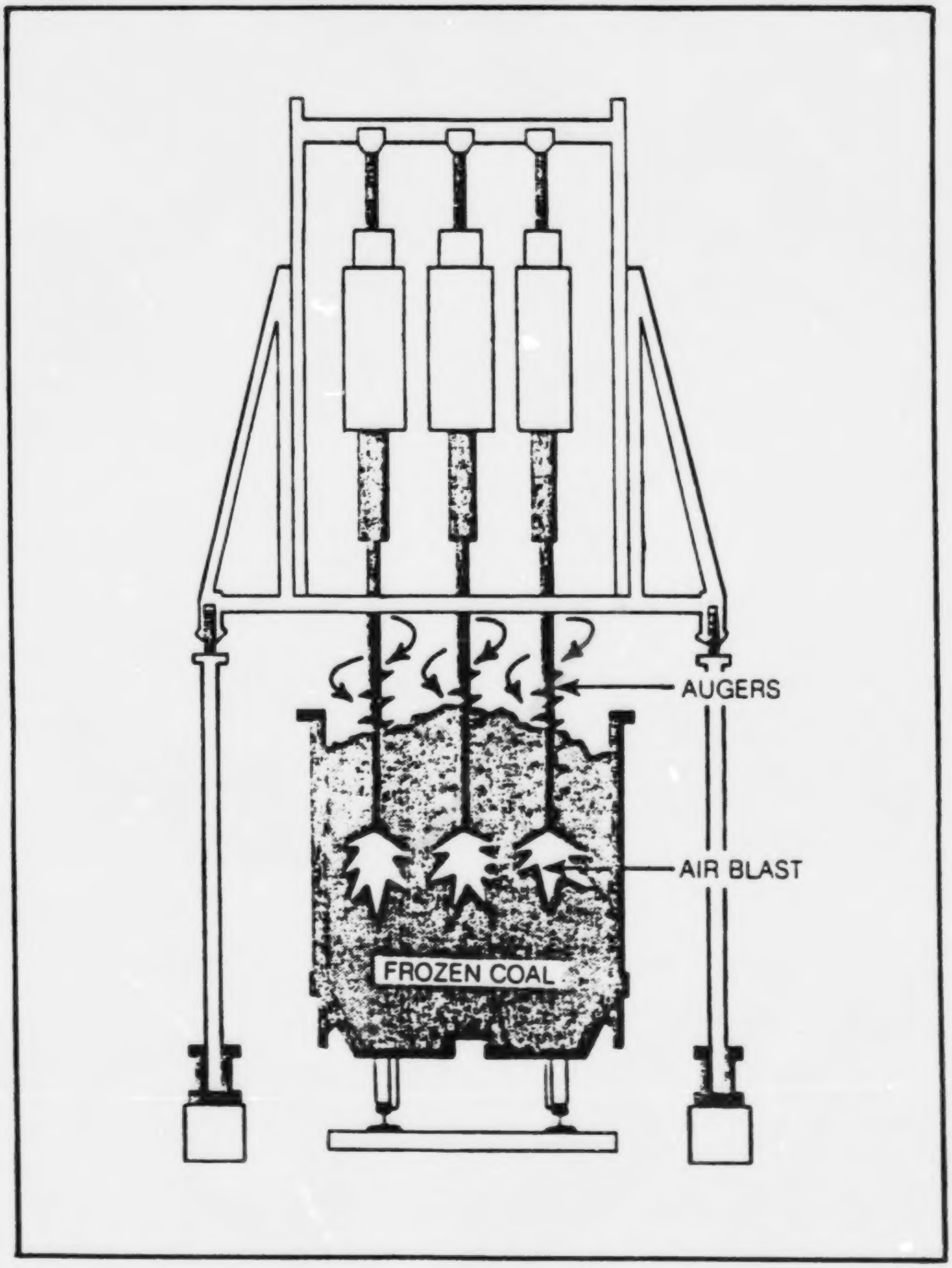
AUGERS
AIR BLAST
FROZEN COAL

Figure 14. Hopper Popper [186]

oxygen or air as the oxidizer. It appears that this concept was never accepted as a practical method of dealing with the frozen coal problem.

Water Jets

High pressure hot water jets have been used by a number of operators to remove any frozen coal that remains attached to the walls of the car following dumping [186]. The procedure has generally proved satisfactory although it requires relatively large amounts of hot water and is fairly labour intensive. The use of very high pressure jets of a hot calcium chloride solution to unload frozen coal will be discussed in a separate section.

SURFACE HEATING METHODS

Introduction

The heating of the surface of a rail car containing frozen coal in order to allow the coal to be removed from the car has long been used. Early methods included starting a fire under the car or applying gas burning torches to the outer surface of the car. Fires were fuelled using any available combustible material including old tires and oil soaked wood and cloth. Considerable damage was often done to the car. These primitive methods were extremely inefficient and only used in emergency situations. From these early methods has evolved the modern thawshed which can be used on a routine basis and when the shed is properly designed, cause no damage to the rail cars. Of course, heating with hand torches is still sometimes used in emergency situations.

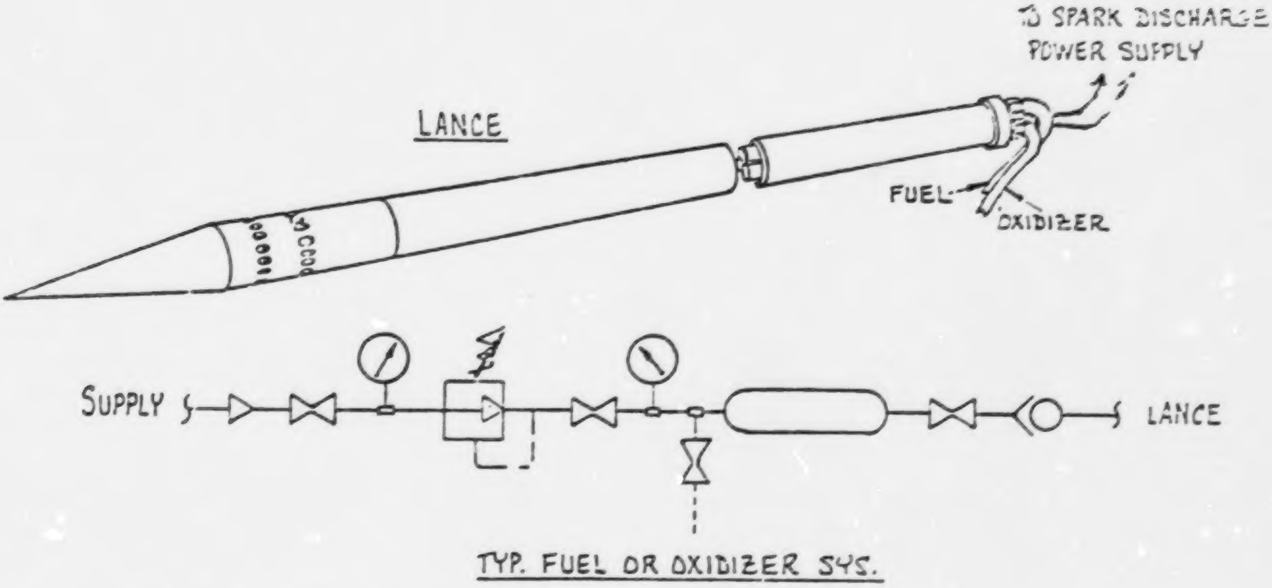
TO SPARK DISCHARGE
POWER SUPPLY
LANCE
FUEL
OXIDIZER
SUPPLY
LANCE
TYP. FUEL OR OXIDIZER SYS.

Figure 15. NASA Lance [212]

Thawsheds

A thawshed is some form of enclosure which can house one or more rail cars and in which some sort of heater is used to thaw the coal (see Figure 16). In general, the car may be left in the shed for a long enough period of time to entirely thaw the coal or it may simply stay in the shed long enough to break the bond between the frozen coal and the surface of the car. In the latter case, the still frozen coal that is discharged from the cars after they have passed through the thawshed must be mechanically broken up and this will be discussed later.

The heaters used in thawsheds may be electrical radiant heaters or gas or oil fired heaters that produce both radiant heating and convective heating of the cars as the hot combustion gases pass over them. The earlier gas or oil fired heaters were usually of the "hot dog" type and consisted basically of a six to eight foot long section of pipe with a diameter of roughly six inches and usually with a series of holes drilled in their surface, see Figure 17. A gas or oil burner at one end of the pipe heated the pipe to a high enough temperature to produce significant radiant energy and the hot combustion gases and heated air flowed up from the heater to produce convection heating. In early applications of the "hot dog" type heater there was often no thawshed used but subsequent developments of this type of heater have been used a the thawshed.

More modern types of gas burning heaters produce much higher levels of infrared radiation than the "hot dog" heater and are generally much more efficient. In these heaters some form of refractory material, such as ceramic, is heated to a high temperature by the combustion producing the radiation. Some measurements of the relative performance of various types of heaters are given in reference [32].

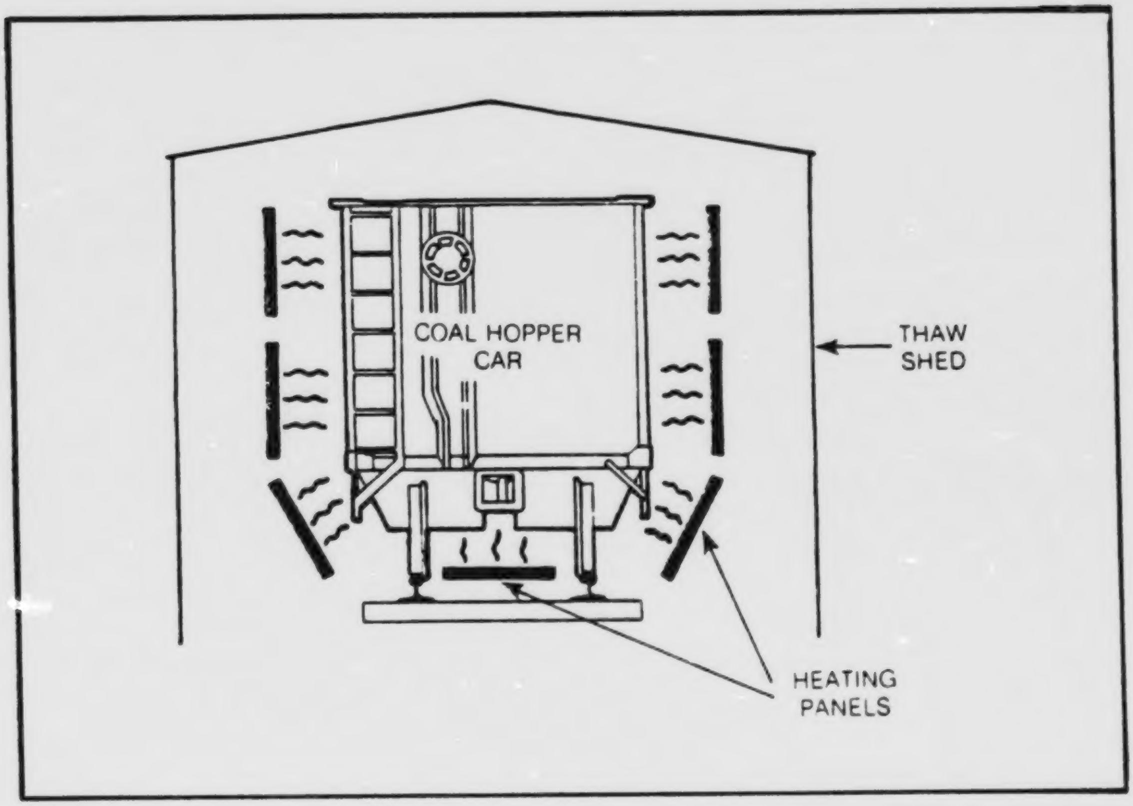
COAL HOPPER CAR
THAW SHED
HEATING PANELS

Figure 16. Thawshed [186]

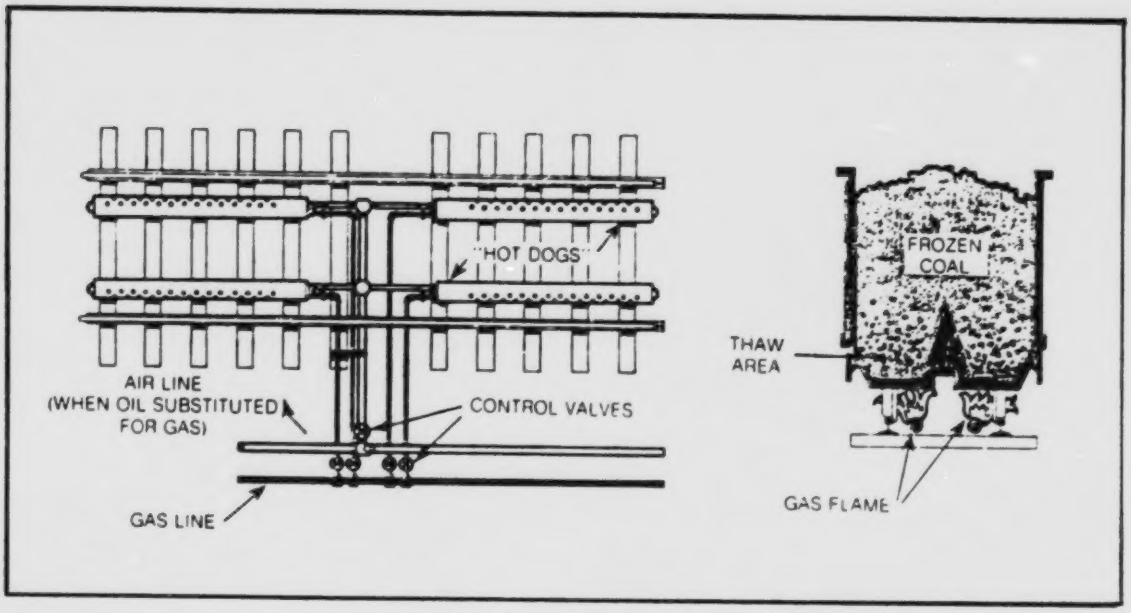
"HOT DOGS"
AIR LINE
(WHEN OIL SUBSTITUTED
FOR GAS)
CONTROL VALVES
GAS LINE
FROZEN
COAL
THAW
AREA
GAS FLAME

Figure 17. Hot Dog Heater [186]

Most modern thawsheds are designed so that only the bond between the frozen material and the surface of the car is broken, this being mainly accomplished using infrared heating. The thawing sheds usually house from one to seven cars and each rail car will typically spend between ten and thirty minutes in the shed although it is only irradiated for part of this time, the rest of the time being to allow the surface heat to "soak" into the coal. When the car leaves the thawshed there is still a considerable crust of frozen coal and this must be broken up after discharge. This is usually accomplished by dumping the frozen coal onto a grid some ten to twenty feet below the track. The frozen coal that does not pass through the grid is then broken up by using some form of mechanical device such as a hammer mill (see Figure 18). It is generally believed that a well designed modern thawshed is a very effective method of dealing with the frozen coal problem when used in conjunction with modern rail cars having smooth internal surfaces. These thawsheds can be designed so that no damage occurs to the cars in the shed. Thawsheds deal, of course, with the frozen coal problem after it has occurred and need, therefore, only be used when necessary. Thawsheds, however, involve relatively high capitol costs [63] and are not really suitable for situations where freezing of the coal is a relatively rare occurrence.

Microwave Heating

The radiant heating systems currently used to thaw rail cars are relatively inefficient in converting the potential energy of the fuel into heat that actually reaches the frozen coal. It has often been suggested that some sort of microwave heating system would be much more energy efficient. A detailed discussion of the potential for this type of heating is given in reference [72]. The general conclusions were that the method is technologically feasible but that there are likely to be significant possible health hazards to working personnel and that the initial and operating costs are likely to be much more than those of existing tech-

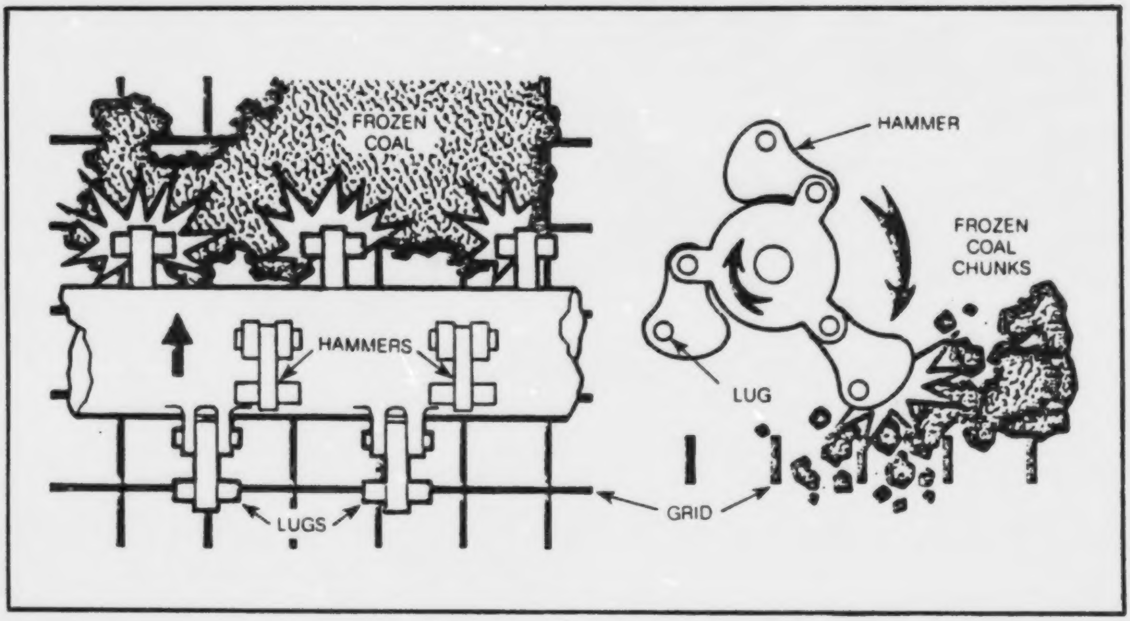
FROZEN COAL
HAMMERS
LUGS
GRID
HAMMER
LUG
FROZEN COAL CHUNKS

Figure 18. Hammer Mill [186]

niques in dealing with the frozen coal problem. The feasibility of using such a device in the Canadian situation should probably, however, still be investigated.

Other Heating Systems

Another form of heating system is described in reference [46]. Basically, it consisted of two induction heaters mounted in wooden panels which were pressed against the sides of the car. The system was installed in 1969 and was used on cars carrying iron ore concentrates. At that time, it did not appear that many more installations of that type were contemplated although the system was working successfully.

CALCIUM CHLORIDE

Although calcium chloride has often been suggested for use as an FCA or SRA, the discussion here is with its use as a freeze point suppressant and thus as a thawing agent.

One of the most widely discussed [37] and [157] methods of using calcium chloride involves spraying a liquid solution over the surface of the frozen coal in the car (see Figure 19) and allowing it to trickle down through the coal. The solution thaws the frozen mass by "dissolving" the ice. The solution used for this purpose is typically about 30 per cent calcium chloride and the application rate is typically about four gallons per ton. Of course, as the calcium chloride solution trickles down through the coal, melting the ice, the solution becomes weaker and the application rate therefore depends to some extent on the moisture content of the coal. The period of time required for the complete penetration of the solution depends of course on the extent of the freezing and the size of the coal car. Typically, it may range from four to ninety-six hours. This time can be reduced if the solution is heated before spraying. The use of calcium chloride solutions in this way is usually reserved for emergency treatment of the frozen coal problem.

A more cost effective way of using calcium chloride is in the high pressure washing out of any frozen coal that remains in the rail car after dumping. Spraying the inside of the car with a 30 to 50 per cent calcium chloride solution at a pressure of 5,000 to 10,000 psi using a lance has been found to be very effective ([107] and [109]). This procedure usually only requires about five minutes per rail car.

Considerable concern about the corrosive effects of calcium chloride on rail cars and on the equipment that uses the coal after it has been treated has been expressed over the years. Most studies have indicated that calcium chloride corrosion of rail cars is not a significant problem because the calcium chloride is only applied during the winter months and its chemical reactivity is low because of the low temperatures involved ([33] and [107]). Any calcium chloride remaining in the cars after the winter should be removed by water spraying. In fact, studies have indicated that the combination of rain and the corrosive constituents of coal cause more corrosion in the rail cars during the summer months than calcium chloride does in the winter months ([33] and [107]).

While the use of calcium chloride could potentially cause corrosion problems in coal burning equipment, no clear results proving that this is the case have been obtained. In general, though, it is probably always preferable to allow as much as possible of the calcium chloride solution to drain off of the coal prior to the firing of the coal. It has also been suggested that any corrosive effects can be reduced by adding small amounts of lime or sodium chloride to the solution as an inhibitor.

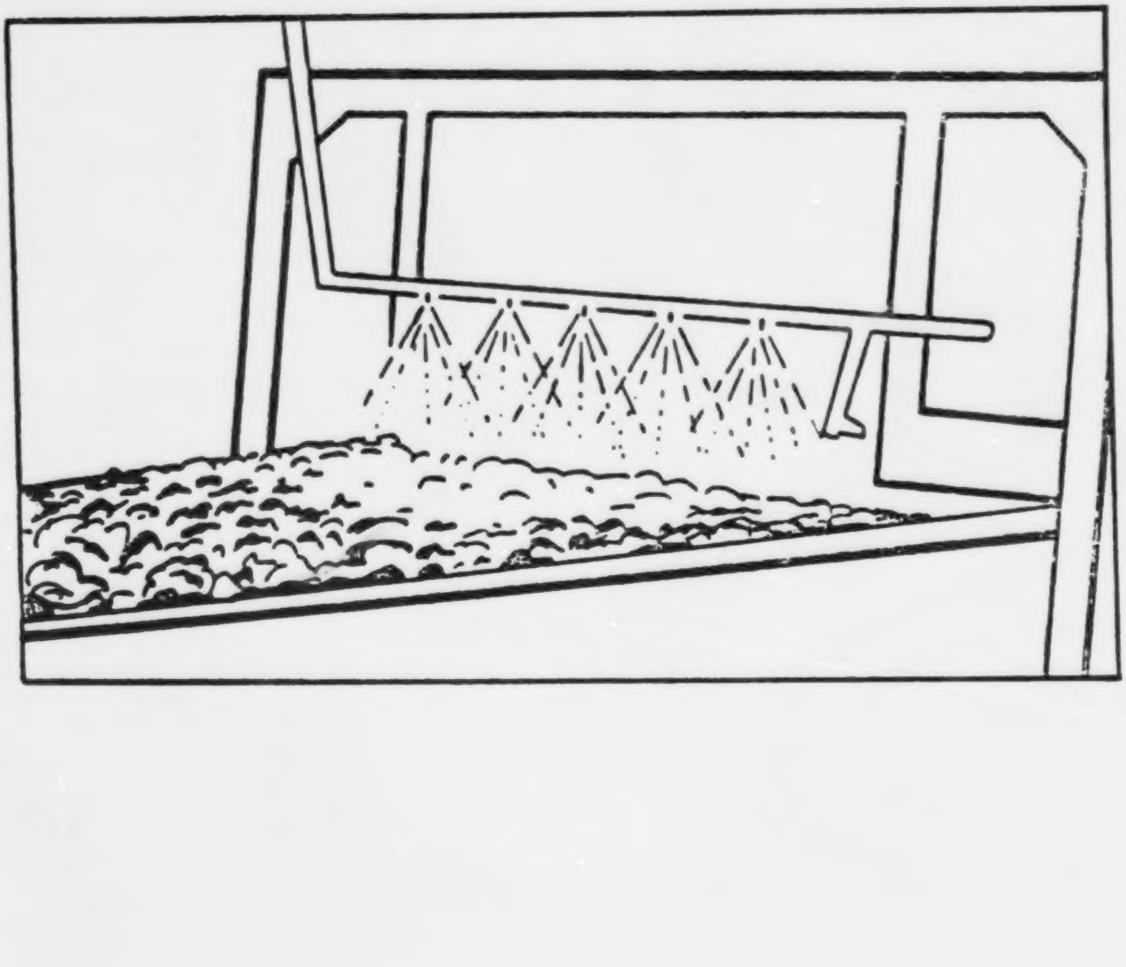

Figure 19. Calcium Chloride Spray System [48]

Experience has generally indicated that when properly used and applied, calcium chloride is an effective method of dealing with some aspects of the frozen coal problem and that it does not cause significant corrosion [47]. By itself it does not appear to be the solution to the coal freezing problems in Canada. However, in combination with other approaches it appears to have potential.

DRYING

As mentioned earlier, coal will only freeze if surface moisture is present, i.e. if the moisture content is above some critical value which depends on the type of coal and the fineness of the coal. One method of avoiding any freezing problems would therefore be to dry the coal below this critical value prior to loading it into the rail cars. There are other advantages to drying the coal ([29] and [94]), some of these being:

- lower transportation costs
- increased boiler efficiency if the coal is used for this purpose
- improved quality of coal for special purpose uses such as the production of coke and chemicals

However, there are also, of course, disadvantages with drying the coal, some of these being:

- the increased costs associated with an increase in dryer capacity
- increased dusting problems
- the dried coal is more susceptible to spontaneous combustion
- the dried coal is more friable with the result that there is a greater degradation in particle size distribution during handling

For coal drying to be a practical method of dealing with the coal freezing problem, it is necessary that the cost savings achieved as a result of drying be great enough to outweigh these disadvantages. It was concluded [29] that coal drying was most likely to be economically feasible when the distance over which the coal was being transported was relatively large, say over one thousand miles.

Thermal drying is the most usually considered method of further decreasing the moisture content of the coal. In a well planned system, this should also allow the coal to be loaded into the rail cars at a temperature that is well above ambient which further reduces the extent of the frozen coal problem. An alternative method for reducing the moisture content of the coal that has been considered [48] involves the use of chemically assisted coal dewatering. The use of such chemicals can significantly increase the amount of surface water that is removed from the coal by existing centrifugal drying equipment and some cost estimates have been made that suggest that this could be an economical method of dealing with the coal freezing problem.

Of course, most of the advantages that arise from drying the coal prior to shipment disappear if the coal is significantly rewetted by precipitation during the journey or as the result of there being snow in the cars when the coal is loaded into them.

It perhaps should also be noted that some of the disadvantages associated with the transportation of dried fine coal could be alleviated by briquetting the fines [94] although this in itself also involves some disadvantages.

SEGREGATION OF FINES

Because the fines have a higher surface moisture content than the coarse coal, the fines have a higher frozen bond strength. One method of trying to deal with the frozen coal problem [30] and [186] is, therefore, to try to spread relatively coarse coal on the bottoms and sides of the car and to have the fines directed to the centre portion of the car where there is less likelihood of freezing. Such a procedure will obviously involve greater loading costs but has apparently proved successful in at least one case.

ABSORBANTS

The coal freeing problem could, of course, be alleviated by mixing a material with the coal that would absorb the surface moisture. The only successful application of this method appears to have been in the "freezeproofing" of lignite in the late fifties and early sixties. The procedure involved the mixing of dried fines with the natural lignite [48] and [74]. The dried lignite fines absorbed much of the moisture from the natural lignite [74] which considerably reduced the strength of the frozen bond thus reducing the severity of the freezing problem. The successful application of this method involved loading the dried fines principally near the walls of the car. The dried fines may also have reduced the strength of the frozen bond in much the same way as an FCA.

OPERATIONAL EXPERIENCE

The purpose of this section is to try to review some of the experiences reported by various companies in the use of different methods of dealing with the frozen coal problem. Some of these experiences have already been referred to or used in discussing the effectiveness of various methods of dealing with the frozen coal problem.

Some operational experiences concerning the use of FCAs will first be discussed.

The Union Electric Company has reported quite extensively on their experiences with the use of FCAs ([30], [180] and [181]). While the coal was shipped in a part of the United States that had relatively moderate winters, some difficulty with freezing had been encountered. They first tried FCAs in the winter of 1978-1979 but met with limited success. This was thought to have been due to improper distribution of the FCA and an improper treatment rate and these problems were subsequently corrected. Because the climatic conditions under which the coal is shipped is so variable, they attempted to only us FCAs when necessary. For this purpose they made use of the so-called Coal Exposure Index or Rosenberg-Doerr number. This is given by:

$$R = (32 - T)t$$

where T is the mean ambient temperature during the journey in degrees Fahrenheit and t is the total exposure time in hours. The basis for the use of this criterion will be discussed in the section on modelling. Union Electric employed a weather forecasting service to provide long range weather forecasts. Using the forecast mean ambient temperatures, they would work out the expected R value for the journey and then would expect the following based on their practical experience:

- if $R < 118$ no freezing problems would be expected and no FCA treatment would be undertaken.
- if $118 \geq R < 225$ freezing problems were expected and the coal was treated with FCAs. Clean dumping was then expected.

- if $225 \geq R < 470$ treatment with FCAs was undertaken but it was expected that additional action would be required in order to dump the cars.
- if $R \geq 470$, while treatment was undertaken. hard frozen slabs still formed and they experienced considerable difficulty in unloading the cars.

The overall experience of Union Electric indicated that FCAs were helpful but expensive and that a truly successful frozen coal handling strategy would probably have to involve FCAs in combination with thawsheds and shakers. Their experience seemed to indicate that the use of the Cold Exposure Index was useful in planning the strategy to be adopted for dealing with the frozen coal problem. It is perhaps worth noting, at this point, that a thirty-six hour rail journey at a mean ambient temperature of 5 degrees Fahrenheit (a not totally unusual set of conditions in Canada) gives an R value of 972 which clearly indicates that FCAs are not likely to be effective in many situations encountered in Canada.

Toledo Edison has also reported on their experiences with the use of FCAs ([30] and [114]). They found that oil based FCAs were more effective than glycol based FCAs. They also found that the success of the FCA depended on the amount of surface moisture and when the free surface moisture content was greater than about seven and one half percent, treatment was ineffective. They also appear to have found that a combined approach using FCAs and a thawshed was the most effective.

Overall, experience seems to indicate that FCAs are really only effective by themselves when the extent of the freezing problem is relatively minor and that when major freezing problems exist they can at best be expected to be of use as part of a combined method of approach.

Russian experience with FCAs is reported in the publication with the Holding Number of 239 in the list of late acquisitions (Appendix D). Their experience seems to be generally positive although it does not appear clear from this publication exactly what type of substance was being used as the FCA.

Consideration will next be given to the use of SRAs. Relatively little has been published in the general literature concerning operational experience with this method of dealing with the frozen coal problems. Some studies of the use of light oil spraying of the inside of coal cars just prior to loading has been reported ([125], [182] and [186]). These studies indicated that a uniform spray was required if any success was to be achieved. However, even when this was done, the results were generally rather inconclusive. The use of surface oil spraying just after unloading has also been tried ([186] and [199]). This dislodges any frozen coal that remains attached to the surface and also prevents the wetting of the interior surface of the rail car during the return journey. The results with this method have also been inconclusive. There is basically no published operational experience that suggests that the use of this type of approach will be very successful under most Canadian conditions.

Consideration will next be given to some reported operational experiences with the use of thawsheds. It appears to be generally accepted (e.g. see [132]) that in dealing with the coal freezing problem the thawshed should be designed to break the bond between the coal and the surfaces of the car and not to fully thaw the coal. As mentioned before, this requires that other steps be taken to break up the frozen bulk of the coal. All recent reports on thawshed operations (e.g. see [133], [182], [185] and [186]) are very positive. All of these reports suggest that if well designed rail cars are used and if the heaters in the thawshed are properly placed (see [133]) then clean unloading of the cars can essentially always be achieved using a thawshed provided this thawshed is large enough. Perhaps the best example of such a thawshed is still that at Thunder Bay. Thawsheds in the United

States have tended to be smaller than that at Thunder Bay because they are required for a smaller portion of the year. These thawsheds will then sometimes not result in the complete unloading of the cars, some coal being left bonded to the surface of the car after dumping. When this occurs, which is rarely, subsidiary methods are used to remove it such as calcium chloride washing or mechanical devices. The economic viability of a thawshed depends, of course, on the type of coal being transported, the length of the journey, the ambient temperature and the number of months in the year in which freezing problems are likely to occur.

Of the other methods of dealing with the frozen coal problem that have been discussed before little real information concerning their true effectiveness under operational conditions appears to be available in the published literature. Detroit Edison reports satisfactory experience with the use of high pressure lances that spray a thirty-five per cent solution of calcium chloride into the coal. These lances were used to deal with coal that had been transported over a relatively short distance (500 miles) at relatively moderate ambient temperatures. The cars were rotary dumped without any treatment and any coal that was left behind frozen to the surface of the car after dumping was removed using these calcium chloride lances. The lances were operated by persons on a foot bridge under which the cars passed after leaving the dumper house.

One point that has been made by many people in discussing their experiences in dealing with the frozen coal problem, e.g. see [19] and [41], is that a multi-pronged approach to dealing with the problem usually proves to be the best. It also appears clear from the literature that there is no single best method of dealing with the problem and that each situation has to be separately evaluated and a unique approach that best suits each such situation has to be developed.

MATHEMATICAL MODELLING

Mathematical models of the freezing of the coal in a rail car are useful for a number of reasons. These include:

- Prediction of when freezing is likely to occur and, therefore, when treatment is required.
- Prediction of how much freezing is likely to occur. This information is useful in deciding on how to deal with the coal freezing problem.
- By using the models in conjunction with empirical information, they can be used in the design of devices that are used to deal with the frozen coal problem.

The simplest model assumes that the depth of freezing can be adequately determined by using the mean conditions that exist during the journey and by assuming that the depth of freezing is dominated by the latent heat that must be removed. Therefore, if a unit surface area is considered and if Q is the amount of heat removed through this unit area of the rail car during the journey, then:

$$Q = h(T_w - T_a)t \tag{1}$$

where:

h = the mean heat transfer coefficient existing during the journey
t = the time of the journey
T_w = the mean wall temperature during the journey
T_a = the mean ambient temperature during the journey

If, as mentioned above, it is then further assumed that the heat removed from the coal is dominantly the latent heat, then:

$$Q = m_f \rho \, d \, L \tag{2}$$

where

m_f = the free moisture content of the coal on a mass basis

ρ = the density of the coal

d = the depth of freezing

L = the latent heat of water

Also, if the latent heat dominates the process, the wall temperature will remain close to the freezing temperature of the water and equation (1) becomes:

$$Q = h(T_f - T_a)\, t \tag{3}$$

where

T_f = the freezing temperature of water.

Combining equations (2) and (3) then gives:

$$d = \frac{h(T_f - T_a)\, t}{m_f \rho \, L} \tag{4}$$

If a particular type of coal is being considered and if h can be assumed not to vary significantly (a reasonable assumption), equation (4) gives:

$$d \propto (T_f - T_a)\, t \tag{5}$$

The right hand side of this equation is what is known as the Cold Exposure Index or Rosenberg-Doerr number. In evaluating this number the temperature difference is usually expressed in degrees Fahrenheit and the time in hours. The above equation then shows that the Cold Exposure Index is simply a rough measure of the depth of freezing. It should be noted from the above analysis that when a particular value of the Cold Exposure Index is used to determine when treatment is required, this value will be unique to the particular type of coal being considered.

The above type of analysis is quite inadequate when long journeys with relatively large changes in ambient conditions are involved. In such situations, a much more refined analysis is required. One of the earlier such analyses was that undertaken at U. S. Steel [45]. This was a one-dimensional treatment carried out on an analogue computer. A more refined analysis of the problem is described in references [159], [161] and [162]. One-, two- and three-dimensional implementations of this analysis are described in detail in [160]. The analysis is based on the following main assumptions:

- the coal is homogeneous
- the coal is initially at a uniform temperature
- the moisture content of the coal is uniform when it is loaded into the rail car
- the coal has thermal properties that are independent of temperature before and after freezing although the properties in the frozen and unfrozen states may be different
- freezing occurs at a fixed known temperature
- moisture migration within the coal is negligible
- only the surface moisture freezes

A comparison of the results given by this model with available experimental data indicates that it is capable of accurately predicting the depth of the freezing in the coal. Such an analysis cannot, of course, predict the strength of the frozen bond between the coal particles and between the coal and the surface of the rail car.

It has been suggested that moisture migration plays an important role in determining the strength of the bond at the surface of the car. Some attempts at modelling this migration have been undertaken ([136] and [173]). While the adequacy of these analyses is not really clear, they do indicate that the effects of moisture migration are small which supports the conclusion reached experimentally in references [164] and [194].

TESTING METHODS

In evaluating the effectiveness of methods of dealing with the coal freezing problem it is important to have standard widely accepted test methods for evaluating the effectiveness of the proposed method. Unfortunately, such standard test methods do not really exist. Indeed, it is only in the evaluation of the effectiveness of FCAs that any attempts have really been made to try to develop standard test procedures and these will now be discussed.

Three techniques for testing the effectiveness of an FCA have received fairly wide attention. These are as follows.

Direct Shear Test

This test [145] (see Figure 20) is based on the Jenike Flow Factor test which is widely used in the study of the properties of powders and granular materials. The basic procedure is as follows:

- coal is crushed and screened to a specified maximum particle size
- the moisture content of the coal sample is determined and, if required, the moisture content is increased by the careful addition of water
- the sample material is placed in a shear cell of the type shown in Figure 20 and packed under normal load to achieve a uniform bulk density
- the cell is frozen by placing it in a freezing chamber at a specified temperature
- a shearing force is applied to the material until failure of the sample occurs.

This test is used to determine the effectiveness of an FCA by determining how the shear force at failure varies with the amount of FCA used.

Some problems with repeatability have been experienced with this test. However, provided the diameter of the cell is large compared to the thickness of the upper portion of the test cell, the test has proved to be reasonably satisfactory ([43] and [150]).

Compression Strength Test

Another test that has been extensively used in trying to measure the effectiveness of FCAs is a simple compression strength test (see Figure 21). In this test, the force required to rupture a frozen sample of coal under a compression load is determined. The basic procedure adopted ([48], [114] and [206]) is as follows:

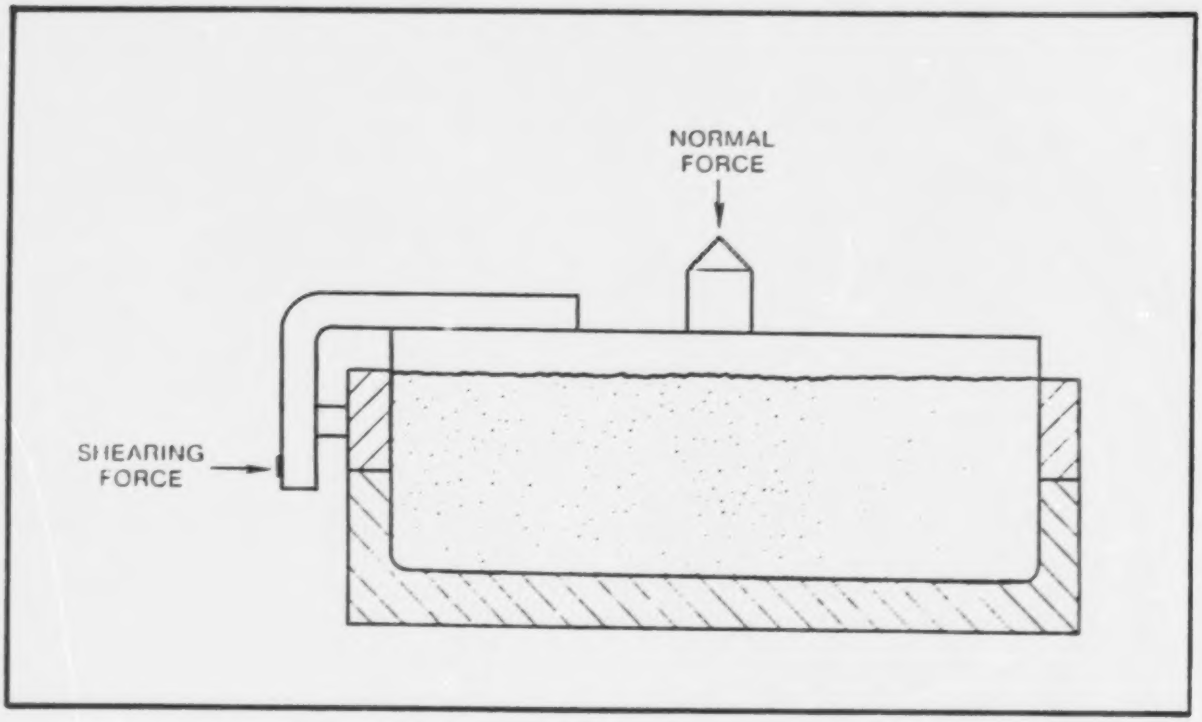
NORMAL FORCE
SHEARING FORCE

Figure 20. Direct Shear Test Apparatus [43]

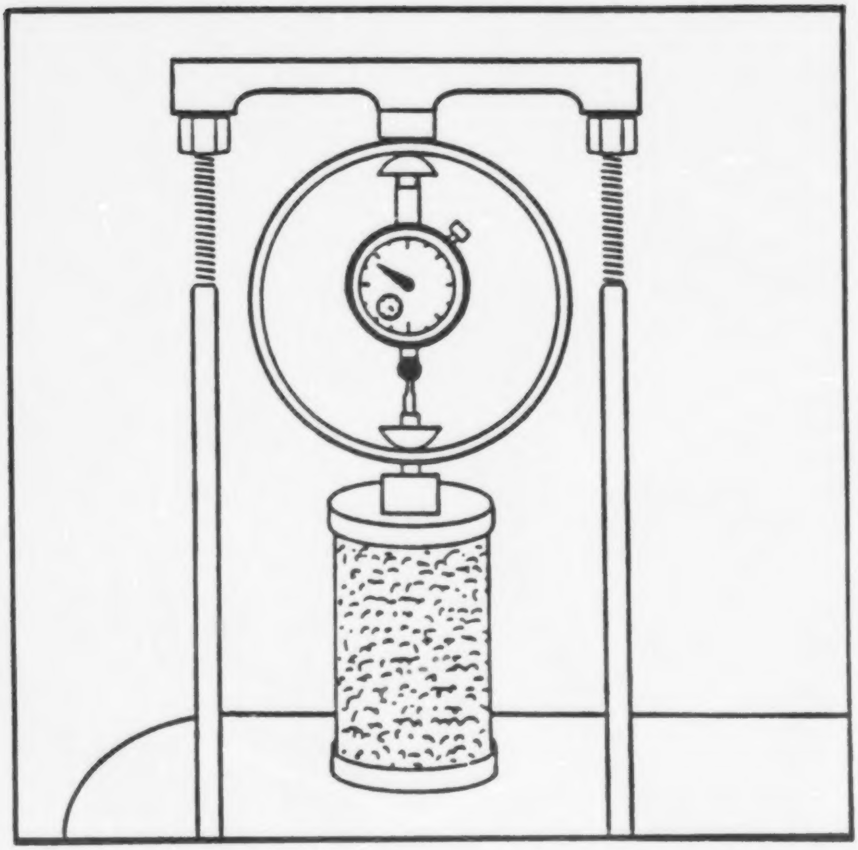

Figure 21. Compression Strength Test Apparatus [48]

- coal is crushed and screened to a specified maximum particle size
- the moisture content of the coal sample is determined and, if required, the moisture content is increased by the careful addition of water
- a plastic cylinder is filled with a sample of the coal and the cylinder is mechanically vibrated to ensure uniform packing
- the cylinder is placed in a freezing chamber and frozen to a specified temperature
- the frozen sample is removed from the cylinder and its compressive strength measured using a standard compression test machine.

The test is not a true representation of the handling problem that occurs in practice but it has been extensively used because it is relatively simple, gives highly repeatable results and does give an indication of the effectiveness of FCA treatment. In order to obtain good readings it is, of course, important to very carefully remove the coal sample from the cylinder in which it is frozen. The height of the sample should also be less than its diameter.

Drop Impact Shear Test

The third type of test that has been used fairly extensively is the so-called Drop Impact Shear Test [218]. This is a modification of the ASTM D-440-49 "Drop Shatter Test for Coal". The basic procedure involved in this test is as follows:

- coal is crushed and screened to a specified maximum particle size
- the moisture content of the coal sample is determined and, if required, the moisture content is increased by the careful addition of water
- the coal sample is packed in a pan that has been sprayed with a silicone oil mold release agent to prevent the sample from adhering to the pan

- the pan is frozen to a desired temperature in a freezing chamber
- the frozen sample is set in a drop box and dropped through a specified distance onto a grizzly
- the coal that passes through the grizzly is collected and weighed
- the coal that does not pass through the grizzly is replaced into the drop pox and dropped from a twelve inch higher level onto the grizzly
- the previous two steps are repeated until all the coal passes through the grizzly

While the test is easy to perform, it has a relatively low degree of repeatability but does give some indication of the effectiveness of a coal treatment.

Of the test methods listed, there are some sections common to all of the procedures. For example, the coal sample which is the most important part of the coal additive testing, must be a good representation of the coal being shipped. There are differences of opinion as to where these coal samples should be taken, i.e. the conveyor belt, rail car or storage pile. One method that seems to work well involves the sampling of three cars from a unit train, typically from the front, middle and rear of the train immediately after it is loaded. These samples are taken from about two feet below the surface and at about eight random points across the car.

Finding the moisture content of the samples is also common to all tests. This is most simply and best accomplished using available methods such as the ASTM D3302 and ASTM D1412 coal moisture content tests. It is very important that all samples have uniform moisture content.

As well as the total moisture content, the surface moisture content should also always be determined. This is best done using ASTM standard tests.

Screening the coal is also important. If the tests are to be repeatable then the samples must always have the same coal size distribution and be well mixed.

The application of the FCA to the sample has been done with eyedroppers, hypodermic syringes and spray bottles. The best method appears to be the use of a spray bottle since it evenly distributes the FCA among the coal particles. Even distribution is essential if an FCA is to function well.

Finally, there is the actual freezing of the sample. The choice of temperature is usually dependent on the conditions experienced by the coal during transport but should be standardized. The duration of the freezing process is chosen for convenience, i.e. one day or overnight.

Presently there is no one technique which provides a good simulation of the problems associated with frozen coal. However, by combining the results from the Compression Strength Test and the Direct Shear Test the effectiveness of an FCA can be adequately determined.

As well as the total moisture content, the surface moisture content should also always be determined. This is best done using ASTM standard tests.

The tests described above are all basically intended to measure the effectiveness of FCAs and possibly calcium chloride treatments. No widely accepted test for measuring the effectiveness of SRAs has been developed. There is probably a need to develop a set of tests that can be used to measure the effectiveness of all methods of dealing with the frozen coal problem including mechanical devices.

ECONOMICS

The publications surveyed contain little up to date information on the relative costs of the various methods of dealing with the frozen coal problem. The available cost studies (Ontario Hydro and Ford and Bacon) appear to have been mainly undertaken in the 1970s. There appears, therefore, to be a great need for up to date economic studies applicable to the Canadian situation.

CONCLUSIONS

It will be seen from the above review that many methods of dealing with the frozen coal problem have been suggested and tried. It appears that:

- Freeze Conditioning Agents work when the ambient temperatures are relatively moderate but have proved relatively unsuccessful in other situations.
- Surface release agents and surface treatments show promise but more testing needs to be undertaken.
- Mechanical devices appear most suited to situations where the ambient temperatures are relatively moderate, the journey times are relatively short and where freezing is only an intermittent problem.
- Thawsheds in which the frozen coal is mechanically broken up after discharge from the car work well but are expensive and best suited to those

situations where severe ambient conditions occur and where freezing is a problem over a significant portion of the year.

- A combination of methods has often proved to be the best way of dealing with the frozen coal problem.
- Sound and up-to-date economic comparisons of the various methods of dealing with the frozen coal problem under Canadian conditions are not widely available.

PART D - TELEPHONE SURVEY

INTRODUCTION

In attempting to decide on future solutions to the frozen coal problem in Canada, it is necessary, of course, to have a comprehensive overview of the present severity of the problem and of the methods presently being used to deal with the problem. In order to partially develop such an overview, a telephone survey was undertaken. This survey involved contacting various persons in the mining, utility, chemical and transportation industries across Canada and the United States. Although the major emphasis was on the Canadian problem it appeared necessary, for several reasons, to contact some U.S. companies. The purpose of the telephone survey was then to inquire about coal freezing problems presently being encountered and of methods presently being used to deal with this problem and to determine who is paying for these procedures for dealing with the coal freezing problem. An attempt was also made in the survey to find out what the respondents felt should be done in the future to deal with the problem and what applied research and development needs were perceived.

PROCEDURE

A questionnaire that would act as the basis for the interviews was first developed. This questionnaire contained a series of specific questions with space for general comments. Not all of the questions were appropriate to all of those interviewed and shortened forms of the questionnaire were used in some cases. A copy of the questionnaire is given in Appendix E.

A list of people in the coal mining industry was generated with the help of the Coal Association of Canada. This list was then expanded to include additional people from companies such as Ontario Hydro, CP Rail, Inland Steel and several unloading docks. The people on the list were then contacted and an appointment time for a half hour (maximum) interview was made. After the interviews had been completed, some of the companies that had severe freezing problems were called again to obtain additional information. The completed interview forms are given in Appendix F. These forms contain the notes made by the interviewer and in no way are these notes to be construed as verbatim quotations from the person being interviewed nor are these persons to be assumed responsible in any way for the content of the completed questionnaire.

In addition to the companies mentioned above, several chemical companies were also contacted in order to determine what chemicals were available for dealing with the frozen coal problem. The information sent by these chemical companies was, as already mentioned, also incorporated into the collection of publications.

A full list of persons interviewed along with some notes about the chemical companies is given in Appendix G.

DISCUSSION

A list of persons interviewed and a very brief summary of some results of the interview is given below:

Richard Ansley
Manager of Marketing and Transportation
Crows Nest Resources
Calgary, Alberta
Interview: yes - brief
Problem: no (but they use FCA and SRA)

David Atkinson
Senior Process Engineer
Manalta Coal Ltd. (Gregg River)
Hinton, Alberta
Interview: yes - full
Problem: very minor

Alvin Bhattal
Vice President Operations
Thunder Bay Terminals
Thunder Bay, Ontario
Interview: yes - full
Problem: no - thawshed works well

Bill Blackeman
Conservation and Protection
Environment Canada
Hull, Quebec
Interview: yes - brief
Problem: we have no comment from him about this

J. W. Bosse
Manager
Obed Mountain Coal Co.
Hinton, Alberta
Interview: yes - brief
Problem: no

John Campel
Research Engineer
Cape Breton Development Corporation
Sydney, Nova Scotia
Interview: yes - full
Problem: yes

Andrew Carmichael
Assistant Manager
Swan Wooster
Vancouver, B.C.
Interview: yes - full
Problem: no when coal goes to receiver with thawshed, yes when coal goes to receiver without thawshed

Bruce Cliburn
Process Control
Cape Breton Development Corporation
Sydney, Nova Scotia
Interview: yes - full
Problem: yes

Doug Cope
Transportation Systems Division
Industrial Programs Branch
Environment Canada
Hull, Quebec
Interview: yes - brief
Problem: see interview

Emile Dubois

Transportation Manager
Luscar Ltd.
Hinton, Alberta
Interview: yes - brief
Problem: minor - they live with carry back coal in bad weather

David Farrell
Senior Representative for Obed Mountain
Obed Mountain Coal Company Ltd.
Calgary, Alberta
Interview: yes - brief
Problem: no

Mike Forbes
Preparation Plant Manager
Luscar Ltd.
Hinton, Alberta
Interview: yes - brief
Problem: very minor

Terry Garvey
Director of Transportation
Westar Mining Ltd.
Vancouver, B.C.
Interview: yes - brief
Problem: very minor if any - live with carry back coal if it happens

Grant J. Goddard
Coordinator-Marketing Services
Esso Resources Canada Ltd.
Calgary, Alberta
Interview: yes - full
Problem: very minor problem

Mike Haddad
Section Manager of Raw Materials Coordination for Coke and Iron Production
Inland Steel
Chicago, Illinois
Interview: yes - full
Problem: yes, but chemicals cured it

Edger Horner
Plant Superintendent
Smokey River Holdings Ltd.
Grande Cache, Alberta
Interview: yes - full
Problem: yes

Fred Komenac
Supervisor Cold Preparation Technology
Westar Mining Ltd.
Balmer Operations,

Sparwood, B.C.
Interview: yes - brief
Problem: no comment from him about this

Lewis Levasseur
Information Services Analyst
Ridley Terminals
Prince Rupert, B.C.
Interview: yes - full
Problem: no - use thawshed

Frank Legrove
President
Donnleey Transport
Montreal, Quebec
Interview: yes - full
Problem: yes

Lorne Lyndon
Supervisor Marketing Services
Fording Coal
Calgary, Alberta
Interview: yes - brief
Problem: no problems - live with three weeks of carry back coal

R. D. Rae
Transportation Coordinator
Manalta Coal
Calgary, Alberta
Interview: yes - brief
Problem: no comment from him about this

Diego Romero
Supervisor Plant Engineer
Crows Nest Resources
Sparwood, B.C.
Interview: yes - full
Problem: no (but they use FCA and SRA)

Peter Salerno
Supervisor
Ontario Hydro
Toronto, Ontario
Interview: yes - full
Problem: no

Brent Sands
Vice President Operations
Neptune Terminals
Vancouver, B.C.
Interview: yes - full

Problem: only with compacted snow in cars which forms layer of ice

Rob Selone
Senior Process Engineer
Quintette Coal Ltd.
Tumbler Ridge, B.C.
Interview: yes - brief
Problem: no

Harold Tardt
Traffic and Contract Administrator
West Shore Terminals
Roberts Bank, Delta, B.C.
Interview: yes - full
Problem: very minor problem

George Tyson
Director of Marketing (non-ferrous metals and mines)
C.P. Rail
Montreal, Quebec
Interview: yes - full
Problem: yes - occasionally

Neil Vigor
Marketing Manager
Teck Corporation
Vancouver, B.C.
Interview: yes - full
Problem: no - use thawsheds and they work well

The results of the telephone survey indicated that the nature of the freezing problem varied widely in Canada and that there is presently no single specific solution to this problem, a solution that works for one company often not being feasible for another. Another point that was clearly indicated was that while there are many potential methods of dealing with the frozen coal problem, many of these have to be ruled out for economic reasons.

The severity of the coal freezing problem encountered depends, of course, largely on the geographic regions in which the coal is loaded and across which it is transported. Coal mined in Alberta and British Columbia and shipped westward encounters relatively minor freezing problems. When the weather conditions in British Columbia are such that the coal is likely to freeze, most of the mines either ship to Prince Rupert where there is a thawshed that apparently works satisfactorily or they live with the carry back coal. Coal shipped from the west to Thunder Bay is frozen for a significant part of the year. However, the thawshed at Thunder Bay appears to be working very well and no difficulties in unloading the frozen coal from the rail cars appear to arise. For shipments from the west to Inland Steel in Chicago, a chemical treatment program using both FCAs and SRAs is employed. The treatment is paid for by Inland Steel and the program was set up by them. Severe coal freezing problems are encountered by Cape Breton in the east. The coal is washed but not thermally dried and is shipped with a relatively high moisture content. The climate is relatively severe and constantly changing. The rail cars used are bottom dumping and thawsheds are not used. All of these factors add up to what appears to be one of the worst coal freezing problems in Canada.

The results of the interviews with people from Ontario Hydro, Thunder Bay Terminals and Ridley Terminals indicates that thawsheds are a very effective solution to the coal freezing problems. The thawsheds used heat the cars for a long enough period of time to break the bond between the frozen coal and the surface of the car. The coal is then dumped onto a grizzly and broken up using mechanical devices. However, thawsheds involve a fairly high initial capitol cost and are not practical for small operations.

Several companies have conducted tests on the use of freeze conditioning agents and side release agents. Of these companies, only two of those surveyed were still using these chemicals, these being Inland Steel in Chicago and Cape Breton in Nova Scotia. Inland Steel set up their own program and believes that it is working satisfactorily. Cape Breton contracted to B. G. Roberts Chemicals to develop a program for them. According to a representative of Cape Breton, the program has only been of limited success and has proved to be relatively expensive. Of the other companies that have tested FCAs and SRAs the general opinion appeared to be that these chemicals were too expensive and were not always effective. In some cases it was decided that having carry back coal was less costly than using a chemical treatment program. Calcium chloride has also not been used anywhere to a significant extent mainly because of fears about its corrosive effects on the rail cars and steam generating equipment.

It was also clear from the interviews that the extent of the coal freezing problem encountered is dependent to a significant extent on the type of rail car used. Bottom dumping cars appear to cause the worst problems.

Snow build-up in the cars on the return trip can also create severe problems when the coal is loaded on top of this snow. None of the mines surveyed cleaned out the rail cars before loading because of time constraints and high delay charges. It was felt by some that since the railways benefit from a reduction in the frozen coal problem, they should allow more time for the mines to properly clean out the cars.

The persons interviewed were also asked whether they were interested in a meeting or symposium to discuss the Canadian coal freezing problem. Many companies felt that they were coping adequately at the moment and may not be interested in attending. However, if new markets were in the offing they may be more interested. If the meeting or symposium were concerned with coal transportation issues in general, it is likely that it would attract more interest.

CONCLUSIONS

Most Canadian companies are coping with the coal freezing problem having implemented a solution that is practical for them. These solutions are not necessarily the best but have proved to be relatively economical. No single method appears to work in all situations although, when it is economically feasible, a thawshed should always be considered. While Canadian companies are dealing adequately with their present problems it is not clear that they are ready to deal with coal freezing problems that could arise with new and expanded markets.

PART E - CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

As already mentioned, it appears that no universally satisfactory single method of dealing with the coal freezing problem exists. Canadian coal industries do experience significant problems with coal freezing. They have, in the majority of cases, arrived at solutions to these problems that are satisfactory for their own particular situation. However, it appears that if new markets are to be developed, new methods of dealing with the coal freezing problem may have to be implemented.

RECOMMENDATIONS FOR APPLIED RESEARCH PROJECTS

Although many solutions to the frozen coal problem have been proposed and tried, it is clear that no single universal solution exists and that more research is required to assist in the selection of the method or combination of methods that best suits a particular situation. A list of such applied research projects that it appears would be of assistance to the Canadian situation is given below.

- An economic evaluation of the various methods of dealing with the frozen coal problem in Canada needs to be undertaken. A series of routes should be selected and for each of these the costs of various potential methods of dealing with the frozen coal problem should be evaluated. This study should assist operators in deciding on what method to use on a new route [63].
- The development of a sound, widely accessible data base should be continued. This development was, of course, started as part of the present study. The new work would involve adding to and updating the existing data base and modifying the keywords somewhat.

- Development of a standard method for testing the effectiveness of Freeze Conditioning Agents and the use of this test in a study of the effects of the amount of FCA and the ambient temperature on the frozen strength of various Canadian coals. This study would indicate whether FCAs are really of use in a majority of Canadian situations.
- The development of a test procedure for measuring the surface bond stress between frozen coal and a metallic surface and the use of this test in the study of the effectiveness of Surface Release Agents and Surface Coatings with Canadian coals. Some full scale testing of Surface Coatings should also be undertaken.
- A definitive study of the potential corrosive effects that result from the use of calcium chloride to deal with the frozen coal problem.
- A study of the feasibility of using ultrasonic vibrators to deal with the frozen coal problem. This would involve a comprehensive literature survey supported by laboratory and full scale testing. It should include a sound economic analysis of this approach to the frozen coal problem.
- A study of the environmental effects of using various chemicals to deal with the frozen coal problem. This study should deal in detail with the Canadian situation.
- A study of how the costs of dealing with the frozen coal problem should be incorporated into coal purchasing contracts
- The development of a comprehensive handbook on the frozen coal problem
- A study of the effectiveness of existing Canadian thawsheds and the development of design procedures for such thawsheds.

OTHER RECOMMENDATIONS

It is recommended that a workshop and seminar on coal transportation problems be organized. Such a meeting should deal not just with the frozen coal problem but with other problems such as that of dusting.

It is also recommended that some fundamental research on the nature of the bond between the frozen coal and the metallic surface of the rail car be undertaken. This work should be based on the extensive studies undertaken in other fields such as the study of aircraft icing.

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Appendix E. QUESTIONNAIRES USED IN THE TELEPHONE SURVEY

Phone call no. ____

COAL COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact ____________________ Title ____________________

Company ____________________ Date ____________

Address ____

Telephone ________________

PART A
(Type of Coal)

1. **Amount of coal shipped**

   A) Tons per day ________________

2. **Type of coal shipped**

   A) Metallurgical
   B) Bituminous Low Volitile
   C) Bituminous High Volitile
   D) Sub - Bituminous
   E) Anthracite
   F) Lignite
   G) Both Metallurgical and Steam
   H) Other ________________________________

3. **Condition of coal shipped**

   A) Raw coal
   B) Washed coal
   C) Washed coal and thermally dried
   D) Other ________________

4. **Is coal pre-heated?**

   A) Yes Temperature ? ______
   B) No

5. **Size of coal shipped**

   ____

6. **Total moisture content when loading**

   ____

7. **Estimated surface moisture content when loading**

   ____

PART B
(Comments)

1. Comment on the freezing problems that you encounter.

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PART C
(Railway cars)

1. **Car ownership**

   A) Railroad
   B) Receiver
   C) Shipper

2. **Type of car**

   A) 100 ton hoppers
   B) Random hoppers
   C) Rapid discharge hoppers
   D) High capacity gondola with braces inside
   E) High capacity gondola without braces inside
   F) Other ______________________________

3. **Special car characteristics**

   A) Insulated
   B) Lined
   C) All Aluminum
   D) None
   E) Other ____________________

4. **Are cars cleaned before loading ?**

   A) Yes
   B) No

5. **Is snow removed before loading ?**

   A) Yes
   B) No

6. **Location of receiver** (ie. distance travelled)

   ____

7. **Loaded transit time**

   ______________ ______________

8. **Do cars return with residual coal?** (how much)

   ____

9. **Is there any damage to the cars?**

   ____

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   A) Yes
   B) No (goto question 7)

2. **Who operates the thaw sheds?**

   ____

3. **Thaw sheds**

A) Number of Cars ____________________
B) Number of tracks ____________________
C) Average temperature ____________________
D) Average car time in shed ____________________
E) Type of heaters and fuel ____________________

____

Comment on their effectiveness ____________________

____

____

____

4. **What was the capital cost of the thaw shed?**

____

5. **How much is it to operate?**

____

6. **Who pays?**

____

7. **Are any mechanical or other devices used to separate the coal?** (explain)

____

____

____

____

____

8. **Who pays for these?** ____________________

Side Release Agents

9. **Are Side Release Agents used?**

A) Yes
B) No

10. Have you considered using them or done any research into them?

____

____

____

If yes, then answer 11 through 21.

11. Product (Brand Name)

____

12. Who is your chemical supplier?

____

13. Period of application

A) All winter
B) Based on weather predictions
C) Based on weather service consultant
D) Other ______________________________

14. Litres of SRA used per car:

____

15. Who specifies treatment guidelines?

A) Customer (contracted/not contracted)
B) Your own company
C) Railroad (contracted/not contracted)
D) Other ____________________

16. Who pays for treatment?

A) Customer
B) Your own company
C) Railroad
D) Other ____________________

17. Who installed and maintains the spray equipment?

A) mine
B) receiver
C) chemical supplier

18. Initial capital cost of spray equipment

____

19. Cost of treatment per car

____

20. Do you find excessive corrosion due to this application

21. Comment on effectiveness of treatment

Freeze Conditioning Agents

22. Are Freeze Conditioning Agents used ?

A) Yes
B) No

23. Have you considered using them or done any research into them?

If yes, then answer 24 through 35.

24. Product (Brand Name)

25. Who is your chemical supplier?

26. Period of application

A) All winter
B) Based on weather predictions
C) Based on weather service consultant
D) Other

27. Litres of FCA used per ton:

28. Coal flow rate at point of application (T/hr)

29. **Who specifies treatment guidelines ?**

    A) Customer (contracted/ not contracted)
    B) Your own company
    C) Railway (contracted/ not contracted)
    D) Other ______________________________

30. **Who pays for treatment ?**

    A) Customer
    B) Your own company
    C) Railroad
    D) Other ______________________________

31. **Who installed and maintains the spray equipment?**

    A) mine
    B) receiver
    C) chemical supplier

32. **Initial capital cost of spray equipment**

____

33. **Cost of treatment per ton**

____

34. **Do you find excessive corrosion due to this application**

____

35. **Comment on effectiveness of treatment**

____

____

____

1. **Are you currently using any other methods to solve the problem.**

____

____

____

____

____

____

PART E

1. What applied research and development needs do you feel are neccessary?

______

______

______

______

______

______

PART F

1. Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?

______

______

______

2. Additional Comments

______

______

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______

Phone call no. ____

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact ____________________ Title ____________________

Company ______________________________ Date ____________

Address ____

Telephone________________

PART A
(Type of Coal)

1. **Amount of coal received**

   A) Tons per day ________________

2. **Type of coal received**

   A) Metallurgical
   B) Bituminous Low Volitile
   C) Bituminous High Volitile
   D) Sub - Bituminous
   E) Anthracite
   F) Lignite
   G) Both Metallurgical and Steam
   H) Other ______________________________

3. **Condition of coal received**

   A) Raw coal
   B) Washed coal
   C) Washed coal and thermally dried
   D) Other ________________

4. **Size of coal received**

   ____

PART B
(Comments)

1. Comment on the freezing problems that you encounter.

PART C
(Railway cars)

1. **Car ownership**

A) Railroad
B) Receiver
C) Shipper

2. **Type of car**

A) 100 ton hoppers
B) Random hoppers
C) Rapid discharge hoppers
D) High capacity gondola with braces inside
E) High capacity gondola without braces inside
F) Other ____________________

3. **Special car characteristics**

A) Insulated
B) Lined
C) All Aluminum
D) None
E) Other ____________________

4. **Location of shipper** (ie. distance travelled)

____

5. **Loaded transit time**

____

6. **Do cars leave with residual coal?** (how much)

____

7. **Is there any damage to the cars?** (explain)

____

____

____

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

A) Yes
B) No (goto question 7)

2. **Thaw sheds**

A) Number of Cars ____________________
B) Number of tracks ____________________
C) Average temperature ____________________
D) Average car time in shed ____________________
E) Type of heaters and fuel ____________________

____

Comment on their effectiveness ______________________________

____

____

____

3. What was the capital cost of the thaw shed?

____

4. How much is it to operate?

____

5. Who pays?

____

6. Are any mechanical or other devices used to separate the coal? (explain)

____

____

____

____

____

____

____

7. Who pays for these? ____

8. Is the coal treated with Freeze Conditioning Agents before shipping?

____

9. Is the coal treated with Side Release Agents before shipping?

____

10. Who requested these?

A) Utility
B) Railroad
C) Mine

11. Comment on the effectiveness of this treatment

12. Do you apply any FCA before storage?

A) Yes
B) No

13. Have you considered using them or done any research into them?

If Yes answer 14 to 21

14. Product (Brand Name)

15. Who is your chemical supplier?

16. Period of application

A) All winter
B) Based on weather predictions
C) Based on weather service consultant
D) Other

17. Litres of FCA per ton

18. Initial capital cost of spray equipment

19. Cost of treatment per ton

____

20. Do you find excessive corrosion due to this application

____

21. Comment on effectiveness of treatment

____

1. Is there any power reduction due to frozen coal at unloading point?

A) Yes
B) No

2. Are you currently using any other methods to solve the problem.

____

____

____

____

____

PART E

1. What applied research and development needs do you feel are neccessary?

____

____

____

____

____

____

PART F

1. Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?

____

____

2. Additional Comments

____

____

____

____

____

____

____

Appendix F. LIST OF PERSONS INVOLVED IN TELEPHONE SURVEY

Persons Interviewed

John Campel
Research Engineer
Cape Breton Development Corporation
P.O. Box 2500
Sydney, Nova Scotia
B1P 6K9

Bruce Cliburn
Process Control
Cape Breton Development Corporation
P.O. Box 2500
Sydney, Nova Scotia
B1P 6K9

Diego Romero
Supervisor Plant Engineer
Crows Nest Resources Limited
P.O. Box 2003
Sparwood, B.C.
V0G 2B0

Richard Ansley
Manager of Marketing and Transportation
Crows Nest Resources
P.O. Box 2699, Station M
Calgary, Alberta
T2P 3Y9

Bill Blackeman
Conservation and Protection
Environment Canada
Hull, Quebec

Doug Cope
Transportation Systems Division
Industrial Programs Branch
Environment Canada
Hull, Quebec

Grant J. Goddard
Coordinator-Marketing Services
Esso Resources Canada Limited
237 Fourth Ave. southwest
Calgary, Alberta
T2P 0H6

Lorne Lyndon
Supervisor Marketing Services
Fording Coal
200, 205 - 9th avenue S.E.
Calgary, Alberta
T2G 0R4

Mike Forbes
Preparation Plant Manager
Luscar Limited
Bag Service 2570
Hinton, Alberta
T0E 1B0

Emile Dubois
Transportation Manager
Luscar Limited
Bag Service 2570
Hinton, Alberta
T0E 1B0

R.D. Rae
Tranportation Coordinator
Manalta Coal
734 - 7th Avenue S.W.
Calgary, Alberta
T2P 2M7

David Atkinson
Senior Process Engineer
Manalta Coal Ltd. (Gregg River)
Bag Service 5000 Hinton, Alberta
T0E 1B0

J.W. Bosse
Manager
Obed Mountain Coal Company Limited
Bag Service 7600
Hinton, Alberta
T0E 1B0

David Farrell
Senior Representative for Obed Mountain
Obed Mountain Coal Company Limited
335 - 8th Avenue S.W.
Calgary, Alberta
T2P 2K6

Rob Selone
Senior Process Engineer
Quintette Coal Limited
P.O. Box 1500
Tumbler Ridge, B.C.
V0C 2W0

Edger Horner
Plant Superintendent
Smoky River Holdings Limited
P.O. Box 2000
Grande Cache, Alberta
T0E 0Y0

Neil Vigor
Marketing Manager
Teck Corporation
1199 West Hastings Street
Vancouver, B.C.
V6E 2K5

Fred Komenac
Supervisor Cold Perparation Technology
Westar Mining Limited
Balmer Operations
P.O. Box 2000
Sparwood B.C.
V0B 2G9

Terry Garvey
Director of Transportation
Westar Mining Limited
1176 West Georgia Street
Vancouver B.C.
V6E 4B8

George Tyson
Director of Marketing non-ferrous metals and mines
C.P. Rail
Montreal

Frank Legrove
President
Donnleey Transport
Montreal

Peter Salerno
Supervisor
Ontario Hydro
University Avenue
Toronto, Ontario

Alvin Bhattal
Vice President Operations
Thunder Bay Terminals
Thunder Bay

Andrew Carmichael
Assistant Manager
Swan Wooster
Vancouver, B.C.

Lewis Levasseur
Information Services Analist
Ridley Terminals
Prince Rupert, B.C.

Harold Tardt
Traffic and Contract Administrator
West Shore Terminals
Roberts Bank, Delta, B.C.
V4K 3N2

Mike Haddad
Section Manager of Raw Materials Coordination for Coke and Iron Production
Inland Steel
Chicago, Illinois

Brent Sands
Vice President Operations
Neptune Terminals
Vancouver, B.C.

CHEMICAL COMPANIES

The following companies are sending or have sent information on their chemical products.

Bob Vitale
Midwest Industrial Supply Inc.
P.O. Box 8431
Canton, Ohio
44711
(216) 456-3121

Mrs. Debbie Specker
Pentone Corporation
74 Hudson avenue
Tenafly, New Jersey
07670
(201) 567-3000

Dave Wanker
Cyanamid
American Cyanamid Co.
Industrial Products Division
511 Central Avenue
Charleston, West Virginia
25302

Sherry Coleman
Betz Laboratories Inc.
Trevose, Pa
19047
(215) 355-3300

- there is a definite need to find something that works.
- she sells it but is sceptical about how well it works.
- don't quote her on this

John Lavin
ChemLink
Philidelphia, Pa
(215) 640-2200

- sell FCA that treated 10 million tons of Eastern Bituminous coal last year
- they apply any of the following products at a rate of 2 pints/ton:

1) IPC 1180 - glycol and salt
2) IPC 1190 - magnesium chloride and glycol
3) IPC 1185 - magnesium chloride brine solution
4) IPC 1120 - glycol solution

- also sell a SRA
1) IPC 1170 - glycol and other surfactants
                  - rate of 5-8 gallons per car
- he claims they work and had no problems with them last year

Dale McDonald
Dow Chemical
Halifax, Nova Scotia
(902) 429-5623

- is not sure if they are continuing with their products due to a shortage of glycol

Rick Helton
Wen-Don Corp.
P.O. Box 13905
Roanoke, Virginia
24038

- sells millions of gallons per year from November to March

B.G. Roberts Chemicals Inc.
President
(902) 823-2077

- supplies chemicals to Cape Breton
- they were experiencing 4 to 7% carry back
- Nova Scotia has the worst climate with its rapidly changing temperatures
- coal has high moisture content

- Roberts sells 3 basic groups of products
  1) hydrocarbon base
  2) glycol base
  3) glycol and salt

These are in 2 areas - Freeze Modifiers and SRA

Freeze Modifiers

- has an ethylene and propolyne to which he adds Sodium Acetate to prevent corrosion
- Calcium Chloride is too corrosive and nobody wants it anymore
- He tried a hydrocarbon based product on washed but not dried coal and was successful in (5 to -25 degrres C) weather. He tested 120 cars and it went well.
- glycol works in moderately cold weather (-5 to -30) and most effective at (-8 to -15) range

Side Release Agents

- 3 types

1) hydrocarbon polymer based
2) hydrocarbon creasote based
3) non hydrocarbon based SRA (SR701)

- numbers 1 and 2 he says are no good
- number 3 he used with Cape Breton and had tremendous success

Results of tests at Cape Breton:

- Ran from Dec 11 to March 27
- sprayed 1545 rail cars using 17 to 19 litres per car
- 234000 tons of coal moved at 37.7 cents per ton
- the average number of trips before a new coat was required was 1.8
- used an airless (air pump) spray
- 1200 psi through the compressor
- averages 2 minutes per car to spray

Next year he hopes to have it at:

- 30 cents per ton
- 45 seconds per car to spray
- 2.5 trips per coating

Properties

- dissipates in water
- high affinity for metal
- certain levels of friction reduction properties
- very persistant in traction with metal surfaces

He is totally satisfied with the success of it and claims there is nothing like it.

Appendix G. RESULTS OF TELEPHONE SURVEY

Phone call no. 1

COAL COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact John Campel Title Research Engineer

Company Cape Breton Development Corp. Date May 13,88

Address P.O. Box 2500, Sydney, Nova Scotia. B1P 6K9

Telephone (902) 564-2894

Note: Greg Landry (Research and Development) joined in on the phone at the very end.

PART A
(Type of Coal)

1. **Amount of coal shipped**

   Total output of all 3 mines is 5 million tons/year.

2. **Type of coal shipped**

   High Volitile A Bituminous Coal

3. **Condition of coal shipped**

   2 of the 3 mines ships washed coal
   1 mine does nothing to the coal

4. **Is coal pre-heated?**

   No

5. **Size of coal shipped**

   Prepared coal (-1")

6. **Total moisture content when loading**

   8 %

7. **Estimated surface moisture content when loading**

   7%

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   - Coal freezing is a substantial problem
   - They ship coal to power plants that depend on its arrival
   - Very much difficulty with frozen coal in the cars

PART C
(Railway cars)

1. **Car ownership**

   - They own their own cars

2. **Type of car**

   - 2 types of cars

   1) Rotary dumping cars
   2) Rapid discharge bottom (hopper bottom)
      - they have the most problems with this second type

3. **Special car characteristics**

   None

4. **Are cars cleaned before loading ?**

   No - very tough to and not practical

5. **Is snow removed before loading ?**

   No - rarely

6. **Location of receiver** (ie. distance travelled)

   - By rail to a shipping peir were it then goes around the world
   - Various power plants within the province

7. **Loaded transit time**

   - From 1 hour to 36 hour for the most distant power plants

8. **Do cars return with residual coal?** (how much)

   - Yes especially if you get a thaw then a freeze
   - Up to 10's of tons per car

9. **Is there any damage to the cars?**

   - Not really

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   No, they did have one but the place got closed down. He did not feel it was effective when it was in use.

7. **Are any mechanical or other devices used to separate the coal?** (explain)

   - The coal gets put on a grid or grizzles
   - Sometimes they use a pick and chip it out by hand
   - They saw a travelling hammer mill in the U.S and might install it
     This rides along the top of the cars and hammers out the coal

Side Release Agents

9. **Are Side Release Agents used?**

   Yes

10. **Have you considered using them or done any research into them?**

    - Tried them this past winter
    - Ask Bruce Cliburn for further details

Freeze Conditioning Agents

22. **Are Freeze Conditioning Agents used ?**

    No

23. **Have you considered using them or done any research into them?**

    - Experimented with them and found them to be very effective
    - The cost was too high so they did not use them
    - This was in 1981

24. **Product** (Brand Name)

    Dow 185

25. **Who is your chemical supplier?**

    - Dow Chemical

1. **Are you currently using any other methods to solve the problem.**

They did some test adding calcium chloride and it was effective as a dust control agent. They did not carry this through for the same reasons as the FCA.

PART E

1. **What applied research and development needs do you feel are neccessary?**

Since he found FCA's to be effective in his experiments, he would like to see a cheaper one developed.

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**
Yes it would be a great idea.

2. **Additional Comments**

In Mr. Landry's discussion with Dale Mcdonald of Dow Chemical he thought that they were getting out of this part of the business. Mainly due to the high and increasing price of glycols.

They also tried a glycol and calcium chloride mixture.

Phone call no. 1

COAL COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Diego Romero Title Supervisor Plant Engineer

Company Crows Nest Resources Limited Date May 17,88

Address P.O. Box 2003, Sparwood, B.C. V0B 2G0

Telephone (604) 425-2555

Note: He did not want to reveal the name of the company they deal with in the United States.

PART A
(Type of Coal)

1. **Amount of coal shipped**

- have 2 operating plants
- 1 million tons of metalurgical coal per year
- 700 000 tons of thermal coal per year

3. **Condition of coal shipped**

- all the coal is washed
- metaluglical coal is thermally dried as well

4. **Is coal pre-heated?**

- comes out of thermal dryers at 130-140 degrees F
- by the time its loaded into the trains it's about 80-90 F

5. **Size of coal shipped**

- 50 mm by 0

6. **Total moisture content when loading**

- 8% or less

7. - inherant moisture is about (0.7-1)%
   - therefore surface moisture is approximately 7%

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

- never had any problems
- they ship to two places 1) Roberts Bank
  2) Eastern United States
- there is no problem with Roberts Bank

Their American receiver demands that they put SRA and FCA on their coal prior to shipping. They do not experience any problems with this shippment as well. But there may not of been a problem without the chemicals.

PART C
(Railway cars)

1. **Car ownership**

- all cars are owned by the western mines and serviced by C.P. Rail
- the U.S. steel mill ownes their own cars

2. **Type of car**

- the U.S. customer's cars are bottom dumped
- rest are open cars that are rotary dumped

3. **Special car characteristics**

None

4. **Are cars cleaned before loading ?**

No

5. **Is snow removed before loading ?**

No

6. **Location of receiver** (ie. distance travelled)

- most of it goes to Roberts Bank
- some goes to the U.S steel mill

7. **Loaded transit time**

- 3 to 5 days for the U.S. shippment

8. **Do cars return with residual coal?** (how much)

- sometimes they have
- at most 1-2%

9. **Is there any damage to the cars?**

- no not really

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

No

7. **Are any mechanical or other devices used to separate the coal?** (explain)

- Roberts Band rotary dumps onto a grizzly

Side Release Agents

9. **Are Side Release Agents used?**

Yes, for only the one customer in the U.S.

11. **Product** (Brand Name)

- a proprietory bunch of FCA

12. **Who is your chemical supplier?**

Chemlink
Alber, Pa
(215) 640-2241
Gary Moore
Manager of Operations
(312) 887-4485

13. **Period of application**

- winter months

14. **Litres of SRA used per car:**

- 6-8 US gallons per car

15. **Who specifies treatment guidelines?**

- customer (contracted)

16. **Who pays for treatment?**

- customer

17. **Who installed and maintains the spray equipment?**

    - it was intalled and is maintained by Crows Nest
    - the US steel mill paid for it and has someone monitoring it

18. **Initial capital cost of spray equipment**

    - $30000 - $40000 dollars for both the FCA and SRA equipment

19. **Cost of treatment per car**

    - he did not know

20. **Do you find excessive corrosion due to this application**

    - no, but they have only used it for 1 year

21. **Comment on effectiveness of treatment**

    - they have not had a problem with frozen coal
    - but it may not have been a problem if they did not use it

Freeze Conditioning Agents

22. **Are Freeze Conditioning Agents used ?**

    Yes, only for the US steel company

24. **Product** (Brand Name)

    - something with a glycol base

25. **Who is your chemical supplier?**

    - Chemlink

26. **Period of application**

    - winter months

27. **Litres of FCA used per ton:**

    - 25 - 30 US gallons per minute or
    - 1/2 US gallons per short ton

28. **Coal flow rate at point of application (T/hr)**

    - 2400 tons per hour

29. **Who specifies treatment guidelines ?**

    - customer (contracted)

30. **Who pays for treatment ?**

    - customer

31. Who installed and maintains the spray equipment?

- Crows Nest

32. Initial capital cost of spray equipment

- see SRA

33. Cost of treatment per ton

- unknown

34. Do you find excessive corrosion due to this application

- has not been tested long enough to tell

35. Comment on effectiveness of treatment

- see SRA

1. Are you currently using any other methods to solve the problem.

- no because they have no problem

PART E

1. What applied research and development needs do you feel are neccessary?

- none because they have no problem

PART F

1. Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?

- no because there is no problem

2. Additional Comments

- all the cars are compressed and sprayed with a crust agent to prevent dusting

He has reservation as to how well the chemical is being added to coal. The coal is moving at a rate of 2400 tons/hr and it is only being added at 25 gallons/min. He does not feel that all the coal is getting treated.

Mr. Richard Ansley
Manager of Marketing and Transportation
Crows Nest Resources
P.O. Box 2699
Station M
Calgary, Alberta
T2P 3Y9
(403) 232-4355

I called Mr. Romero first and got most of Crows Nest's information from him. So when I called Mr. Ansley I simply asked for his comments on the situation. They are as follows.

They do not have an enormous freezing problem. With their shipment to Roberts Bank the only time a problem arises is when Vancouver is cold enough to freeze the coal. Then you could get 10 - 20 tons of carry back per car. They do not treat this with any chemicals because the cold weather only last for about one week a year.

The only eastbound shipping they do is to Inland Steel in Chicago. During the summer months it travels by rail to Thunder Bay and then by boat to Chicago. In the winter it must go directly by rail to Inland Steel. During these months Inland Steel has set up and paid for a program which adds both FCA and SRA.

The cars that are used are bottom dumping which helps add to the unloading problem. They use a mechanical shaker that sits on the cars and helps shake the coal free. It takes 2 to 3 times longer to discharge the coal during the winter months.

Mr. Ansley said that Inland Steel seemed to think the chemicals were effective. Crows Nest has done some studies on FCA for use on the western shipments and found that they were not necessary. He does not see the need for a symposium or a meeting to discuss the problem since he does not feel there is one.

Bill Blackeman
Conservation and Protection
Environment Canada
Hull, Quebec
(819) 997-2800

He says his knowledge is minimal and I should be speaking with Doug Cope. He read me a memo that made the following points:

- FCA and certain solutions are effective but way too expensive
- thaw sheds seem to be a more practical and useful solution
- Sweden is using heated coverings on their railway cars with tremendous success
- proposed to use calcuim chloride

Doug Cope
Transportation Division
Environment Canada
Hull, Quebec
(613) 998-9590

He did not have a lot of sympathy towards our project because he feels the technology is avaliable (ie. thaw sheds,FCA,SRA). Companies are too cheap to use the avaliable technology which is too expensive. It is not economically feasible for the companies to use these methods. He feels no applied research should be done in this area without investigating the economic aspects. He also mentioned something about Sweden using automated coal coverings that are heated.

Mr. Cope has delt mainly with anti-dusting agents and not really in FCA. He did however try calcuim chloride once and found it had the following two problems:

1) - reacted to form hydrochloric acid which is corrosive
2) - after combustion it formed sulphuric acid which rots the boilers

One of the biggest problems he found was in the application of these chemicals.

He is sending me some information on various chemicals as well as the following two papers.

1) "A Study of the Mechanical Properties of Frozen Western Candadian Coal."
   By H.B. Engineering Limited for Transport Canada
   TP1507 (1978)

2) "Flow Related Problems in the Distribution of Western Canadian Coal."
   By H.B. Engineering Limited for Transport Canada
   TP826 (1977)

Phone call no. 1

COAL COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Grant J. Goddard Title Coordinator-Marketing Services

Company Esso Resources Canada Limited Date May 18,88

Address 237 Fourth Ave. southwest, Calgary, Canada T2P 0H6

Telephone (403) 237-3737

Note: Esso Resources owns Byron Creek Collieries

PART A
(Type of Coal)

1. **Amount of coal shipped**

   - in 1987 they shipped 775000 tons
   - in 1988 they plan to ship 1 million tons

2. **Type of coal shipped**

   - 60% is thermal coal
   - 40% is weak coking coal

3. **Condition of coal shipped**

   Washed coal and thermally dried

4. **Is coal pre-heated?**

   No, after it is dried it sits in stock piles for 4 days and gets loaded into the train at ambient temperature.

5. **Size of coal shipped**

   (-2)"

6. **Total moisture content when loading**

   - 7% or 8%

7. The inherant moisture content is 1.5% with the rest being surface moisture

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   - not traditionally a problem
   - past 2 years there has been no problem
   - they dry their coal

   Sometimes cars do have coal carry back when they go to Hudsons Bay. These cars are bottom dumped and occationally experience problems.

PART C
(Railway cars)

1. **Car ownership**

   - C.P Rail owns most of their cars
   - the rest are owned by Ontario Hydro

2. **Type of car**

   - most are rotary dumped
   - the ones going to Hudsons Bay are bottom dumped

4. **Are cars cleaned before loading ?**

   No

5. **Is snow removed before loading ?**

   No

6. **Location of receiver** (ie. distance travelled)

   - 60 % to Ontario Hydro
   - next largest shipment goes to Roberts Bank
   - with a small amount going to Hudsons Bay

7. **Loaded transit time**

   - Ontario Hydro is 5 days
   - Roberts bank takes 90 hours

8. **Do cars return with residual coal?** (how much)

   - only sometimes on the ones returning from Hudsons Bay

9. **Is there any damage to the cars?**

   - only sometimes on the ones returning from Hudsons Bay
   - rusted or broken steel members within the car

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

Yes - at Thunder Bay for Ontario Hydro
- also Hudsons Bay

2. **Who operates the thaw sheds?**

- Thunder Bay and Hudsons Bay

7. **Are any mechanical or other devices used to separate the coal?** (explain)

- Roberts Bank and Thunder Bay rotary dump their coal onto blocks

Hudsons Bay has a car shaker to release the coal and if this doesn't work then people with sledge hammers will.

Side Release Agents

9. **Are Side Release Agents used?**

No

10. **Have you considered using them or done any research into them?**

They looked into using SRA in some studies that were done with the coal association. The cost was too high and it was not worth it.

- Mr. Goddard is sending me some information on their studies

Freeze Conditioning Agents

22. **Are Freeze Conditioning Agents used ?**

No

23. **Have you considered using them or done any research into them?**

- same as the SRA
- they looked into it and it was not worth it

PART E

1. What applied research and development needs do you feel are neccessary?

- he stresses the need for applied research
- he doesn't want canmet sitting in the laboritories
- he wants them coming out to the mines and working with these people

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**

No, he does not personally see the need for a symposium. If it was tied together with other transportation issues such as dusting or handling of the coal then he would be interested.

Lorne Lyndon
Supervisor Marketing Services
Fording Coal
200,205 - 9th Avenue S.E.
Calgary, Alberta
T2G 0R4
(403) 264-1063

- they ship to 3 places 1) Thunder Bay Terminals
  2) Roberts Bank in B.C.
  3) Inland Steel in Chicago
- do not experience any freezing problems
- do not apply any kind of FCA or SRA, nor is it neccessary to start using them
- it is impossible to clear out the snow before loading and this helps it freeze to the car
- they simply live through the 2 or 3 weeks in which they experience carry back coal

Thunder Bay deals with the coal using their thaw shed to release it, followed by mechanical devices which crush the blocks.

Inland Steel set up and pays for FCA and SRA to be added before shipping.

Another possible contact at the mine is Joe Andrusiak (superintendent of Processing). (604) 865-2271

Mike Forbes
Preparation Plant Manager
Luscar Limited
Bag Service 2570
Hinton, Alberta
T0E 1B0
(403) 692-3763

- do not experience difficult problems with frozen coal
- load coal at 95 degress F then it's up to C.N. to get it into the sun belt in the mountains as fast as possible
- if C.N. has a problem and the coal gets frozen then they set that car aside until it thaws
- they ship coal with very low moisture content taking it from 8% down to 5.5%
- they coat it with a latex seal to help control dusting
- they do not use FCA or SRA of any kind

Emile Dubois
Transportation Manager

- they ship 5 million tons of coal per year from several mines
- both metallurgical and thermal coal
- they ship to Thunder Bay Terminals, Nanacoke and vancouver
- they wash and thermally dry their coal
- Luscar looked into FCA in the past and found you would have to treat all the coal in the winter and this would be to expensive
- they simply put up with the carry back coal during the bad weather
- he does not see the need for research and development because vancouver is a moderate climate
- nor does he see the need for any kind of a symposium or a meeting to discuss the problem

R. D. Rae
Transportation Coordinator
Manalta Coal Ltd. (Gregg River)
734-7th Avenue S.W.
P.O. Box 2880
Calgary, Aberta
T2P 2M7
(403) 294-5080

- Mr. Rae said I should talk to Mr. Atkinson
- he is curious as to what canmet is doing

Phone call 1

COAL COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Dave Atkinson Title Senior Process Engineer

Company Manalta Coal Ltd. (Gregg River) Date May 16,88

Address Bag Service 5000 Hinton, Alberta T0E 1B0

Telephone (403) 692-3977

Note: Mr. Atkinson was a little reluctant to give information out over the phone.

PART A
(Type of Coal)

1. **Amount of coal shipped**

   - they have the capacity to ship 2.2 million tons per year
   - he did not want to give me the exact figures

2. **Type of coal shipped**

   Metallurgical

3. **Condition of coal shipped**

   Washed coal and thermally dried

4. **Is coal pre-heated?**

   No

5. **Size of coal shipped**

   (-2)"

6. **Total moisture content when loading**

   8%

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   For the past 2 summers he has not experienced coal problems because they have had mild winters. Occasionally coal adheres to the bottom and part way up the sides of the car.

   He feels it does not matter what the climate is like anywhere along the route of the train. The only place that matters is at the loading dock in Alberta. If the temperature is below -20 degrees F then the coal will freeze to the cars.

PART C
(Railway cars)

1. **Car ownership**

   - C.N. Rail

2. **Type of car**

   - rotary dumper

3. **Special car characteristics**

   - none

4. **Are cars cleaned before loading ?**

   No

5. **Is snow removed before loading ?**

   No

6. **Location of receiver** (ie. distance travelled)

   - Roberts Bank

7. **Loaded transit time**

   - 2 days one way

8. **Do cars return with residual coal?** (how much)

   - if the temperature is below -20 degrees F in Alberta then they will experience carry back coal

9. **Is there any damage to the cars?**

   Not to his knowledge but he may not know.

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   No

   He does not know what happens when they unload at Roberts Bank.

Side Release Agents

9. **Are Side Release Agents used?**

No

10. **Have you considered using them or done any research into them?**

- Yes they are currently testing them
- he was very tentative about commenting on it

Freeze Conditioning Agents

22. **Are Freeze Conditioning Agents used ?**

No

23. **Have you considered using them or done any research into them?**

- no they have not looked at these

PART E

1. **What applied research and development needs do you feel are neccessary?**

- he says research and development is a always good
- but he did not give me any specifics
- they are doing research and development on their own on SRA

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**

- No it is low priority on their list

2. **Additional Comments**

- freezing effects them because they don't get to ship as much coal if there is carry back

J.W. Bosse
Manager
Obed Mountain Coal Company Limited
Bag Service 7600
Hinton, Alberta
T0E 1B0
(403) 865-7600

- Obed does not experience any problems at all
- very free running coal (low grade sub - bituminous B)
- has a problem with spontaneous combustion
- he sends his coal out hot through B.C. in up to -50 degrees C and still doesn't experience any problems
- the railroads give him cars with residual coal in them because Obed cleans them out so well

David Farrell
Senior Representative for Obed Mountain
P.O. Box 999
335 - 8th Avenue S.W.
Calgary, Alberta
T2P 2K6
(403) 268-0176

- they have absolutely no problem with frozen coal

Rob Selone
Senior Process Engineer
Quintette Coal Limited
P.O. Box 1500
Tumbler Ridge, B.C.
V0C 2W0
(604) 242-3221

They do not have any coal freezing problems. They do not get any carry back coal at all. The only problem is if it sits on a side embankment and freezes up. Then they simply drop it from 10 feet onto a grid and it crushes into pieces for loading.

Phone call no. 1

COAL COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Edger Horner Title Plant Superintendent

Company Smoky River Holdings Limited Date May 18,88

Address P.O. Box 2000, Grande Cache, Alberta. T0E 0Y0

Telephone (403) 827-3711

PART A
(Type of Coal)

1. **Amount of coal shipped**

   - 1.4 million tons per year

2. **Type of coal shipped**

   Metallurgical

3. **Condition of coal shipped**

   Washed coal and thermally dried

4. **Is coal pre-heated?**

   - sits in a pile after the thermal dryers and gets loaded at ambient temperature

5. **Size of coal shipped**

   1.5 by 0

6. **Total moisture content when loading**

   (5.5 - 6.5)%

   - the inherent moisture is 0.2%
   - the rest is surface moisture

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   - in the 4 corners of the cars they get a build up of frozen coal
   - also in the junction between the floor and wall of the cars
   - usually 2 tons per car
   - can be as high as 10 tons per car

PART C
(Railway cars)

1. **Car ownership**

- they operate with 3 unit trains in total
- 2 are their own on a lease from Procor
- 1 belongs to C.N. Rail

2. **Type of car**

- all rotary dumped

3. **Special car characteristics**

None

4. **Are cars cleaned before loading ?**

No

5. **Is snow removed before loading ?**

- No
- it would take to much time to clean the cars
- they have 4 hours to load the train before they must pay delay charges
- these charges are about $400 per hour

6. **Location of receiver** (ie. distance travelled)

- Neptune Terminals in Vancouver

7. **Loaded transit time**

- 36 hours

8. **Do cars return with residual coal?**

- yes

9. **Is there any damage to the cars?**

- no

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

No

7. **Are any mechanical or other devices used to separate the coal?** (explain)

- they have vibrators at Neptune Terminals

Side Release Agents

9. **Are Side Release Agents used?**

   No

10. **Have you considered using them or done any research into them?**

   - they are going to try some in the fall
   - he did not know any details about it

11. **Product** (Brand Name)

   - 8899

12. **Who is your chemical supplier?**

   - Allchem in Edmonton

Note: The estimated cost of this chemical is set for $15 per car. It is suppose to last for several cycles. He says carry back coal costs his company between $40000 - $50000. This can be as high as $80000.

Freeze Conditioning Agents

22. **Are Freeze Conditioning Agents used ?**

   No

23. **Have you considered using them or done any research into them?**

   They are very conserned about the quality of their coal. They want to produce a very high quality product and are concerned that aditives would effect the coal properties. They are concerned with coking of the coal.

1. **Are you currently using any other methods to solve the problem.**

   - no

PART E

1. **What applied research and development needs do you feel are neccessary?**

   - find a product that garantees release of the coal out of the cars for less then the carry back costs.
   - right now he sees no benefit from the SRA
   - he would like to see the price be $1/car/cycle

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**

   - yes he feels we would receive a lot of interest in this
   - lots of companies are testing things
   - especially if we had a new solution
   - yes he would attend

2. **Additional Comments**

   - suspects the anti-dusting agents contribute to the freezing problem
   - They can not predict the weather and consequently would have to spray chemicals all winter. This gets expensive.
   - Allchem's price of $15 /car or 15 cents per ton to spray is too expensive

Phone call no. 1

COAL COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Neil Vigor Title Marketing Manager

company Teck Corporation Date May 16,88

Address 1199 West Hastings Street. Vancouver, BC. V6E 2K5

Telephone (604) 687-1117

Note: He was a little reluctant to give out information because his V.P. said he should not.

PART A
(Type of Coal)

1. **Amount of coal shipped**

   - 1.7 million per year

2. **Type of coal shipped**

   Metallurgical

3. **Condition of coal shipped**

   Washed coal

4. **Is coal pre-heated?**

   No

5. **Size of coal shipped**

   1.5 "

6. **Total moisture content when loading**

   - no comment

7. **Estimated surface moisture content when loading**

   - no comment

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   They experience coal freezing because it travels through the peace river where it is very cold. It then goes to the Wridley Terminals where it gets heated in their thaw shed. It really is not a problem.

PART C
(Railway cars)

1. **Car ownership**

   - C.N. Rail

4. **Are cars cleaned before loading ?**

   No

5. **Is snow removed before loading ?**

   - he was not sure

6. **Location of receiver** (ie. distance travelled)

   - Wridley Terminals

8. **Do cars return with residual coal?** (how much)

   - no

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   Yes but he does not know any details about their operation.

Side Release Agents

9. **Are Side Release Agents used?**

   No

10. **Have you considered using them or done any research into them?**

    - they do not see the need for SRA.

Freeze Conditioning Agents

22. **Are Freeze Conditioning Agents used ?**

    No they do not see the need for them

1. **Are you currently using any other methods to solve the problem.**

   - it is not really a problem for them

PART E

1. **What applied research and development needs do you feel are neccessary?**

   - none
   - there are enough SRA and FCA out on the market and we don't need to research more of them

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**

   - no

Fred Komenac
Supervisor Cold Preparation Technology
Westar Mining Limited.
Balmer Operations
P.O. Box 2000
Sparwood, B.C.
V0B 2G9
(604) 425-8221

- did some tests a few years ago on some chemicals
- do not presently do any kind of preventative measures when loading the coal
- suggested I speak with Lee Marcony (lab supervisor)

Terry Garvey
Director of Transportation
Westar Mining Limited
1176 West Georgia Street
Vancouver, B.C
V6E 4B8
(604) 681-8222

- do not ship east and consequently do not have a freezing problem
- temperature in the west is usually warm enough that the coal does not freeze
- if it does go below freezing then they simply live with the carry back coal until the temperature rises again
- do not use any thaw sheds or mechanical devices at all

Westar did look into using SRA at one time. It was an Appolo chemical product. He thought the company had gone bankrupt since. This SRA was effective but not economically feasible.

Phone call no. 1

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact George Tyson Title Director of Marketing non-ferrous metals and mines

Company C.P. Rail Date May 12, 88

Address Montreal

Telephone (514) 395-7470
head office: (514) 395-5151

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   - yes they do occasionally have problems with frozen coal
   - sometimes they heat up the cars before unloading
   In one place they simply set fire to the bottom of the cars. This method burnt the gaskits and lines.
   - they tried glycols and they did not always work and were much to expensive so they scrapped it

PART C
(Railway cars)

1. **Car ownership**

   - C.P Rail

2. **Type of car**

   - triple hopper
   - up to 8 unloading gates per car
   - don't help in freezing

3. **Special car characteristics**

   None

6. **Do cars leave with residual coal?** (how much)

   - yes
   - they dig as much out as possible with a back hoe and the rest is left as carry back

7. **Is there any damage to the cars?** (explain)

   [illegible]

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   No

6. **Are any mechanical or other devices used to separate the coal?** (explain)

   - back hoe to dig it out (works well)
   - tried a clamp crain but it damaged the cars a lot

PART E

1. **What applied research and development needs do you feel are neccessary?**

   - develop a glycol that works and is inexpensive

2. **Additional Comments**

   - the glycol that they used was $2 to $4 per ton
   - should speak with Mr. Frank Legrove of Donnleey Transport who does their unloading for them

Phone call no. 1

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Frank Legrove Title President

Company Donnleey Transport Date May 13,88

Address Montreal

Telephone (514) 342-5532

- they unload the C.P. Rail coal in a place just outside of Montreal

PART A
(Type of Coal)

1. **Amount of coal received**

   - 25000 tons per year
   - 5000 or 6000 tons in the winter

2. **Type of coal received**

   Bituminous

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   - do have the problem of freezing coal
   - where they normally would use gravity to unload the coal now they must use a pick and a shovel
   - tried setting fires underneath the cars but was a hazard
   - they used desiel oil as fuel and it made lots of black smoke
   - since it was a pollution hazard they were told to stop
   - chemicals work but not completely

PART C
(Railway cars)

4. **Location of shipper** (ie. distance travelled)

   - from West Virginia

5. **Loaded transit time**

   - 2 weeks experiencing lots of weather types

6. **Do cars leave with residual coal?** (how much)

   - no

   always clean them right out

7. **Is there any damage to the cars? (explain)**

- no

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

No

6. **Are any mechanical or other devices used to separate the coal? (explain)**

- people get in their with picks and shovels

8. **Is the coal treated with Freeze Conditioning Agents before shipping?**

- no

9. **Is the coal treated with Side Release Agents before shipping?**

- no
- they tried some last year and it froze anyway

11. **Comment on the effectiveness of this treatment**

- they tried somekind of FCA last year and it froze anyway
- it was too expensive so they dropped it

12. **Do you apply any FCA before storage?**

No

2. **Are you currently using any other methods to solve the problem.**

- no
- can not afford a thaw shed because they are a small operation

PART E

1. **What applied research and development needs do you feel are neccessary?**

- a FCA that works and is cheap

Phone call no. 1

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Peter Salerno Title Supervisor

Company Ontario Hydro Date May 12, 88

Address University ave. Toronto, Ontario.

Telephone (416) 592-3626
Head office: (416) 592-5111

PART A
(Type of Coal)

1. **Amount of coal received**

   - 3 million tons per year
   - largest user of coal in Canada

2. **Type of coal received**

   Lignite

3. **Condition of coal received**

   Washed coal and thermally dried

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   They do not have any problem what so ever with frozen coal. They thermally dry and wash the coal before loading. Then it is shipped from the west where it freezes. They simply heat it up in the Thunder Bay thaw shed until it thaws. The coal now sits at Thunder Bay until spring when it can be taken by ship to Nanacoke.

   Mr. Salerno says that FCA are a waste if money because the thaw sheds work very well and are cheaper to operate.

4. **Location of shipper (ie. distance travelled)**

   - British Columbia, Alberta and the United States

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   Yes

2. **Thaw sheds**

A) Number of Cars 9
B) Number of tracks 1

Comment on their effectiveness

- extremely good
- Alvin Bhattal gave me a more detailed description of this shed

8. **Is the coal treated with Freeze Conditioning Agents before shipping?**

- no

9. **Is the coal treated with Side Release Agents before shipping?**

- no

12. **Do you apply any FCA before storage?**

No

13. **Have you considered using them or done any research into them?**

Yes they did consider it but it was too expensive and they did not need it

2. **Are you currently using any other methods to solve the problem.**

- no

PART E

1. **What applied research and development needs do you feel are neccessary?**

- none because things are working fine

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**

- no

2. **Additional Comments**

Thunder Bay terminal is owned by Ontario Hydro but is operated independently. After 15 years of operation Ontario Hydro losses ownership of the terminal.

- they apply a latex topping to help contol dusting
- he feels Americans are spending too much money on FCA and thaw sheds are a better solution

Phone call no. 1

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Alvin Bhattal Title Vice President Operations

Company Thunder Bay Terminals Date May 12,88

Address Thunder Bay

Telephone (807) 623-6921

Note: Thunder Bay Terminal is owned by Ontario Hydro but operated separately

PART A
(Type of Coal)

1. **Amount of coal received**

   - in 1987 they received 4.1 million tons of coal

2. **Type of coal received**

   Metallurgical - high and low volitile
   Bituminous
   Lignite

3. **Condition of coal received**

   - steam and metallurgical coal is washed and thermally dried
   - Lignite is neither washed or thermally dried

4. **Size of coal received**

   10" or less
   includes fines

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   - no problems
   - does not become a solid mass
   - it only freezes on the sides about 6"
   - then they thaw it and it gets dumped

PART C
(Railway cars)

1. **Car ownership**

   - owned by Ontario Hydro, C.N. Rail and C.P.Rail

2. **Type of car**

   - rotary dumping

3. **Special car characteristics**

   - sides are toxic painted

4. **Location of shipper** (ie. distance travelled)

   - Byron Creek B.C.
   - Crows Nest B.C.
   - Fording Coal
   - Westar Mining
   - Smoky River

5. **Loaded transit time**

   - 26 hours from Saskatchewan
   - 2.5 days from B.C.

6. **Do cars leave with residual coal?** (how much)

   - sometimes if a car has been left outside an extended amount of time
   - not very often
   - only once have they ever had a complaint

7. **Is there any damage to the cars?** (explain)

   - no

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   Yes

2. **Thaw sheds**

   A) Number of Cars holds 10 but only 6 are heated
   B) Number of tracks 1
   C) Average temperature approx. 180 degrees F
   D) Average car time in shed 90 sec per car
   E) Type of heaters and fuel propane (infrared)

Comment on their effectiveness

- tremendous success

3. **What was the capital cost of the thaw shed?**

   - ?

4. **How much is it to operate?**

   - approx. 3 or 4 cents per ton

5. **Who pays?**

   - Thunder Bay terminals paid for everything in contract with Ontario Hydro

6. **Are any mechanical or other devices used to separate the coal?** (explain)

   The coal falls into a hopper which then falls onto a grizzly. The fines are able to go through the grizzly onto a conveyer. The chunks that do not fit through the grizzly get put into a rotary crusher.

7. **Who pays for these?** Thunder Bay

8. **Is the coal treated with Freeze Conditioning Agents before shipping?**

   - no

9. **Is the coal treated with Side Release Agents before shipping?**

   - no

12. **Do you apply any FCA before storage?**

    No

13. **Have you considered using them or done any research into them?**

    - the system is working, so why add any unnecessary costs

Phone call no. 1

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Andrew Carmichael Title Assistant Manager

Company Swan Wooster Date May 13,88

Address Vancouver B.C.

Telephone (604) 684-9311

PART A
(Type of Coal)

2. **Type of coal received**

- metallurgical and thermal

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

- they ship to Ridley Terminals in Prince Rupert
- Ridley has a thaw shed
- cars get turned upsidedown and dumped in a hopper
- a hammer mill travels along the grizzles and hammers the coal to the appropriate size

- they also ship to North Shore
- there is no thaw shed here and this presents a problem

PART C
(Railway cars)

2. **Type of car**

- rotary dumping cars

3. **Special car characteristics**

- None

4. **Location of shipper** (ie. distance travelled)

- they ship to Prince Rupert where there is a thaw shed
- also to North Shore Terminals which has no thaw shed

6. **Do cars leave with residual coal?** (how much)

- yes it is much worse without the thaw shed

7. **Is there any damage to the cars? (explain)**

- no

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

Yes at Prince Rupert

2. **Thaw sheds**

A) Number of Cars 6
B) Number of tracks 1
C) Average temperature 144 heaters
D) Average car time in shed 120 seconds
E) Type of heaters and fuel Natural gas

3. **What was the capital cost of the thaw shed?**

- 4 million

4. **How much is it to operate?**

- ?

5. **Who pays?**

- Swan Wooster built them

2. **Are you currently using any other methods to solve the problem.**

- no

PART E

1. **What applied research and development needs do you feel are neccessary?**

- there is a need for a central governing system which decides who pays for the treatment

2. **Additional Comments**

- money is being wasted because of carryback coal

Phone call no. 1

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Lewis Levasseur Title Information Services Analist

Company Ridley Terminals (Prince Rupert) Date May 13,88

Address Prince Rupert B.C.

Telephone (604) 624-9511 ex. 136

PART A
(Type of Coal)

1. **Amount of coal received**

- 6 million tons per year

2. **Type of coal received**

Metallurgical and Thermal

4. **Size of coal received**

(1/2)" or smaller

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

- no freezing problems at all

In the last 4 years they only had 1 or 2 problems. For these they used fire hoses to get all the coal out of the car.

The coal occasionally comes in frozen and they simply use the thaw shed to break the bond between the surface and the coal. later the lumps are broken up into smaller more manageable pieces. These pieces are then piled outside. Prince Rupert is very mild and it only goes below freezing about 1 week a year. It also rains about 260 days a year which helps keep the coal thawed while at Prince Rupert.

PART C
(Railway cars)

1. **Car ownership**

- cars are owned by the two mines that bring them coal
  1) Quintette Coal (division of Denison Mines)
  2) Bull Moose (Teck Corporation)

2. **Type of car**

   - gondola top dumping which gets dumped upsidedown
   - 90 ton cars

4. **Location of shipper** (ie. distance travelled)

   - 900 miles to mine

5. **Loaded transit time**

   - 32 hours away

6. **Do cars leave with residual coal?** (how much)

   - if the coal is properly loaded at the mines then they have no problems
   - if the coal is loaded onto snow then it compacts and creates instant ice

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   Yes

2. **Thaw sheds**

   A) Number of Cars: 8 cars - train drives straight through
   B) Number of tracks: 1
   C) Average temperature: 180 degrees F
   D) Average car time in shed:

   - 9 or 10 min/car could be as high as 15

   E) Type of heaters and fuel: gas furnaces (burners)

   Comment on their effectiveness

   - use it from Nov to Feb
   - very effective

3. **What was the capital cost of the thaw shed?**

   - ?

4. **How much is it to operate?**

   - they pay $15000 per month

5. **Who pays?**

- Prince Rupert pays for everything themselves (ie. capital and operating costs)
- the mines are contracted to bring Prince Rupert X amount of coal per year which they get charged for
- Prince Rupert decides if they want to use the thaw shed or not

6. **Are any mechanical or other devices used to separate the coal?** (explain)

- then they use crushers - breaker bars
- these break into pieces
- then it gets apron fed into a huge catapillar track which crushes it down to 3"
- then it gets put outside where it is exposed to the sun

8. **Is the coal treated with Freeze Conditioning Agents before shipping?**

- no

9. **Is the coal treated with Side Release Agents before shipping?**

- no

- they apply latex cover which acts as an anti-dusting agent

12. **Do you apply any FCA before storage?**

No

13. **Have you considered using them or done any research into them?**

- no because Prince Rupert is only frozen 1 week a year

PART E

1. **What applied research and development needs do you feel are neccessary?**

- none

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**

- no

2. **Additional Comments**

- in the last 4 years there has only been 1 or 2 times when they needed to use fire hoses
- they monitor the temperature of origin to see if it will need the thaw shed
- then they try the first couple to see how they come out

Phone call no. 1

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Harold Tardt Title Traffic and Contract Administrator

Company West Shore Terminals Date May 18,88

Address Roberts Bank, Delta B.C V4K 3N2

Telephone (604) 946-4491

PART A
(Type of Coal)

1. **Amount of coal received**

- they average 5 trains per day
- in 1987 they had
  - 1629 trains
  - 177388 cars
  - 16 million tons

2. **Type of coal received**

- mostly metallurgical
- some thermal

3. **Condition of coal received**

Washed coal

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

- not a very big problem
- they use ice crushers to split it up after it has been dumped
- he says they never have any problems dumping the coal
- however they do get carry back coal but he does not think it's significant

PART C
(Railway cars)

1. **Car ownership**

- C.P. Rail
- C.N. Rail

2. **Type of car**

- rotary dumping

4. **Location of shipper** (ie. distance travelled)

   - comes from Gregg River, Crows Nest and Westar mining

5. **Loaded transit time**

   - 32 hours

6. **Do cars leave with residual coal?** (how much)

   - yes about 2 to 5 tons sometimes as high as 6 to7 tons

7. **Is there any damage to the cars?** (explain)

   - no

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   No

6. **Are any mechanical or other devices used to separate the coal?** (explain)

   - in the dumper they have hammer mills that crush the coal after unloading
   - it usually dumps without problems

7. **Who pays for these?**

   - wholly owned subsidrary of B.C. Resources

8. **Is the coal treated with Freeze Conditioning Agents before shipping?**

   - no

9. **Is the coal treated with Side Release Agents before shipping?**

   - no

   - they apply anti-dusting agents only

12. **Do you apply any FCA before storage?**

    No

PART E

1. **What applied research and development needs do you feel are neccessary?**

   - nothing because he does not consider it a problem

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**

   - he personally was not interested in going
   - but one of the Vice Presidents or the President might be interested

Phone call no. 1

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Mike Haddad Title Section Manager of Raw Materials Coordination for Coke and Iron Production

Company Inland Steel Date May 24, 88

Address Chicago, Illinois

Telephone (219) 399-4830

PART A
(Type of Coal)

1. **Amount of coal received**

   - 3 million short tons per year

2. **Type of coal received**

   - Metallurgical
   - some thermal for their power plants

3. **Condition of coal received**

   - depends on the mine but all is washed and most is dried

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   - yes they did have a problem with frozen coal
   - they hired ChemLink to apply FCA and SRA to all their incoming coal
   - he firmly believes that these chemicals work and stopped all their freezing problems
   - they do have 2 thaw sheds at 2 different unloading docks

PART C
(Railway cars)

1. **Car ownership**

   - depends on the mine

2. **Type of car**

   - hopper

4. **Location of shipper** (ie. distance travelled)

   - western North America

6. **Do cars leave with residual coal?** (how much)

   - no

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   Yes

2. **Thaw sheds**

   - one is electric infrared
   - the other is gas

3. **What was the capital cost of the thaw shed?**

   - ?

4. **How much is it to operate?**

   - ?

6. **Are any mechanical or other devices used to separate the coal?** (explain)

   - they have front end loaders

8. **Is the coal treated with Freeze Conditioning Agents before shipping?**

   - yes

9. **Is the coal treated with Side Release Agents before shipping?**

   - yes

10. **Who requested these?**

    - Inland Steel

11. **Comment on the effectiveness of this treatment**

    - works very well

14. **Product** (Brand Name)

    - 1115 and 1215 are FCA
    - 1170 is a SRA

15. **Who is your chemical supplier?**

    - ChemLink

16. **Period of application**

    - Dec. 15 to Mar. 15

17. **Litres of FCA per ton**

    - for more information talk to the following person
    - Gary Moore (ChemLink) in Chicago at (312) 887-4485

20. **Do you find excessive corrosion due to this application**

    - no

21. **Additional Comments**

    - they have a weather monitoring system which regulates when to apply the chemicals

Phone call no. 1

UTILITY COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Brent Sands Title Vice President Operations

Company Neptune Terminal Date May 24,88

Address Vancouver, B.C.

Telephone (604) 985-7461

PART A
(Type of Coal)

1. **Amount of coal received**

   - 2.8 million last year
   - projected 4 million this year

2. **Type of coal received**

   - mostly metallurgical
   - small amount of thermal

3. **Condition of coal received**

   - all is washed coal

4. **Moisture content**

   5 to 6 % is the target
   4 to 8 % is usually what they get

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   They do not have frozen coal problems. They have a problem with snow piling up in the cars and it compact to form ice. Because of this they get frozen coal to side of the cars. Usually late in the season about march. This is when the snow has had time to pile up in the cars and the coal gets loaded on top of it.

   They use a hammer mill to break up the coal after it has been unloaded.

   Neptune is owned by the mines (Smoky River and Cardinal River) and they don't put any money into Neptune.

   He mentioned something about Sept Iles in Quebec using a jet engine to blow out the snow before loading iron ore.

PART C
(Railway cars)

1. **Car ownership**

   - C.N. Rail

2. **Type of car**

   - rotary dumping

4. **Location of shipper** (ie. distance travelled)

   - Smoky River in Alberta
   - Cardinal River in Alberta

5. **Loaded transit time**

   - 36 hours

6. **Do cars leave with residual coal?** (how much)

   - yes

PART D
(Potential Solutions)

1. **Are thaw sheds used?**

   No

6. **Are any mechanical or other devices used to separate the coal?** (explain)

   - there is a rotary hammer mill on top of the grizzly to crush the coal after it has been dumped

8. **Is the coal treated with Freeze Conditioning Agents before shipping?**

   - no

9. **Is the coal treated with Side Release Agents before shipping?**

   - no

2. **Are you currently using any other methods to solve the problem.**

   - no

PART E

1. **What applied research and development needs do you feel are neccessary?**

   - he would like to see a SRA that lets the snow come free from the side every time.
   - needs something to get rid of residual carry back coal
   - they are losing money everytime coal is carried back

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**

   - yes but he does not want to go
   - should ask the people at the mine to go

2. **Additional Comments**

   - he feels something should be done
   - but when he talks to the mines they don't want to put any money into it

   Possible Contact

   - Fred Nun
     Chief Engineer
     Cardinal River
     (403) 692-3763

Phone call no. [illegible]
called [illegible]

COAL COMPANY QUESTIONNAIRE

- THE HANDLING OF FROZEN COAL -

Contact Bruce Cliburn Title Process Control

Company Cape Breton Development Corp. Date May 10,[illegible]

Address P.O. Box 2500, Sydney, Nova Scotia B1P 6K9

Telephone (902) 564-3889

PART B
(Comments)

1. **Comment on the freezing problems that you encounter.**

   - tried with limited success FCA's and SRA's.
   - FCA were far too expensive
   - SRA were tried this winter with limited success

Side Release Agents

9. **Are Side Release Agents used?**

   Yes this past summer

11. **Product** (Brand Name)

   - SR 701

12. **Who is your chemical supplier?**

   B.G. Roberts Chemical Ltd.
   Tantaloon,Nova Scotia
   (902) 823-2077

   - see chemical section for his comments

13. **Period of application**

   - mid December through all of winter

15. **Who specifies treatment guidelines?**

   - Cape Breton contracted Roberts to do the complete system

16. **Who pays for treatment?**

   - Cape Breton

17. **Who installed and maintains the spray equipment?**

   - Roberts

18. **Initial capital cost of spray equipment**

- ??

19. **Cost of treatment per car**

- ??

21. **Comment on effectiveness of treatment**

- limited success
- expensive
- problem cars were not cleaned out
- sometimes other factors help to cause the coal to freeze
eg. Frozen coal on occasion was loaded into the car which helped promote total freezing.
- they are still deciding whether to continue the process next year
- it is up to Bill McLelan

Freeze Conditioning Agents

22. **Are Freeze Conditioning Agents used ?**

No

1. **Are you currently using any other methods to solve the problem.**

They might install a car shaker at the pier. Probably next year.

PART E

1. **What applied research and development needs do you feel are neccessar**

- none that they can't do

PART F

1. **Do you see the need for a symposium or a meeting to discuss the problem from a Canadian perspective? Would you attend?**

Yes he does and someone from his company would go. Maybe not him.

2. **Additional Comments**

- none